Central Great Plains Research Station

2001 Research Progress Report

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USDA ARS NRCS Colorado State University

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CENTRAL PLAINS RESOURCE MANAGEMENT RESEARCH UNIT

MISSION STATEMENT

To enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for optimal utilization of soil and water resources. Emphasis is on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation.

CENTRAL GREAT PLAINS RESEARCH STATION STAFF

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SUMMARY OF 2001 WEATHER

CENTRAL GREAT PLAINS RESEARCH STATION
AKRON, COLORADO

R. Wayne Shawcroft
Regional Extension Irrigation Agronomist (Retired)
Farm Service Representative, Citizens National Bank of Akron

In contrast to the extreme heat of the summer in 2000, and the very cold November 2000, the main feature of the **Year-2001** weather was the return to more normal conditions. While the **Year-2001** year was slightly warmer than average, and just slightly wetter than average, as a whole, conditions were just about as close to "average" as could occur. One feature that was a significant change was the substantial snowfall. Several periods of 10 to 12 inches of snow occurred in January, February, March, and April. Total snowfall for the January-May 2001 period was 59 inches. This was a significant increase over recent years, since the past several years have been in the less than 20-inch total range.

With the exception of a few records on individual days, no major temperature or precipitation records were set. This was much in contrast to the summer heat of **Year-2000**. While the month of June was the driest of the summer months, with only about 53% of the average for the month, the rainfall distribution was not much below or above average. While rainfall throughout the area was spotty, crop-growing conditions were generally favorable, with some record yields of Proso millet and dryland corn. Wheat yields were not necessarily record setting, but there were not a lot of extremely low yields reported. Pasture and grass conditions were generally favorable throughout the year.

TEMPERATURES

Monthly mean, maximum, and minimum temperatures are shown in Tables 1, 2, and 3 (also see the graph of the Monthly Mean Temperatures). January started out with a little snow cover and a zero degree low on Jan. 1. However, with the exception of three snowy and cold periods during the month, January ended nearly three degrees above average. A late January snow storm and cold winds led to a February that was 3.4 degree colder than average. In fact, February was the only month of the year with a colder than average mean temperature. Two periods in February brought "below zero" temperatures, and the average daily maximum was 4.7 degrees below average. March brought continued cooler temperatures, with below average maximums and slightly above average minimums.

The spring months of April and May were slightly warmer than average, although a new record low minimum of 32 degrees was set on May 24. June and July brought above average temperatures, but not with major heat, as in **Year-2000**. There was an 18-day period from June 23rd to July 10th with 90 degree or greater daily maximums. Minimum temperatures for this same period were in the low 60's, with ties of the record high minimum of 65 degrees on June 30 and July 1. Only two 100-degree maximums occurred during the summer, June 24th and July 6th. August continued as a warm month, but not with record breaking heat. A new record maximum

of 99 degrees was set on Aug. 19th, and a tie of the record high minimum of 67 degrees F occurred on Aug. 6th. September still ranked warmer than average, with nine 90-plus days, with two consecutive days of 91 degrees as late as Sept. 26 and 27. The 91-degree high on Sept. 26 was a new record maximum for the date. No freezing temperature occurred in September. In fact, the first freezing temperature did not occur until Oct. 5, with a 31-degree minimum. The first major "killing" freeze did not occur until a 28 on Oct. 13 and lows of 18 degrees on Oct. 25 and 26th. However, the end of October brought new record high minimums of 45 degrees on Oct. 28th and 31st. This brought on a very warm November, which saw new record high minimums of 40, 38, 36, and 38 set on Nov. 16th, 17th, 21st, and 22nd. The average daily maximum for November was 5.7 degrees above the average and the minimums averaged 3.1 degrees above the average. This mild period was interrupted with a cold, snowy period on Nov. 26th, that brought the first "below zero" temperatures of the winter, and with daily maximums of only 16 degrees on the 26th and 27th. The cold was not long lasting, since mild temperatures returned in December with average maximums 4.4 degrees above average and average minimums 2.2 degrees above average.

The ***average annual mean temperature*** (an average of the daily mean for the 365 days of the year) as shown in the **"Annual Mean Temp."** graph was **50.19 ° F**. This ranks **2001** as the **13th** warmest year on record. For comparison the warmest year on record was 1934 with an average of 52.62 ° F, and the coldest 1912 with an average of 44.81 ° F.

A summary of the **Growing-Degree-Days (GDD)** for the May through September period is shown in Table 4. This was 9.9% above average for the season, and ranked as the **13th highest GDD** accumulation of the 94-year record. The **GDD** accumulation graph shows that the summer was almost exactly "average" until late June, when the summer temperatures increased substantially until the end of September.

PRECIPITATION

The **annual total precipitation for 2001** was **16.78 inches,** which ranks as the **44th wettest** or **51st driest** of the 94-year record. The **May-Sept. period** total was **11.74 inches** compared to the **11.49 inches** average.

The snowfall in mid and late January began a much welcomed snow-cover period. This has been an absent feature of recent winters. An interesting event occurred in late January, that saw several storms resulting in about a 9-inch snow cover on most fields, only to have a severe and strong windstorm on Jan. 31st essentially sweep the fields clean of the protective snow cover. Late February brought another 8-10 inch snowfall resulting in above-average precipitation for both January and February. Mid March brought another 12 inch accumulation and above average precipitation for the 3rd consecutive month. While April was slightly below average for total precipitation, a total of 16 inches of snow did occur. Even a late May (21st) snowfall of one inch was a surprise. In all, there was 32 days of snow cover in the January to May period.

May did bring back the title for the wettest month, with early and late rains making a total of 3.96 inches. June came in as the driest month of the summer, with only 1.32 inches or 1.15 inches below average. July, Aug. and Sept. all brought rains of average to slightly above average. Rainy periods of Sept. 7-8th and 15-18th set up excellent wheat planting conditions. The remainder of the fall period, October until late November was drier and warmer. This dry spell was interrupted

with a substantial snow storm on Nov. 25 and 26th, that resulted in school and road closures for several days. Precipitation for November was 0.78 inches or 0.22 above average. The late November snow had suggestions of a long winter, but warm mild December temperatures returned, and after about 18 days of snow cover most of the snow was gone. Dry conditions prevailed, with December logging not even a "trace" of precipitation. This ties December's of 1908, 1928, and 1996 with "zero" precipitation for the month.

Overall, the 68 inches of total snowfall for the calendar year was a significant change from recent years. Even with this amount of snowfall, temperatures remained relatively mild for this amount of snow and snow cover.

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*The following tables and graphs show other features of the **2001 weather year**, and compare the **2001 season** with the long-term record. This completes the **94th year** of compilation of daily rainfall and temperature records at the Research Station. **Special note – Bob Florian** retired in November of 2001. Bob had been the weather observer and recorder for about 48 years, while at the Research Station. Great job Bob! Thanks.*

TABLE 1. AVERAGE MONTHLY MEAN TEMPERATURES (Based on 8:00 am daily observation time)

2001 TEMPERATURES

USDA-ARS RESEARCH STATION, AKRON, CO

MEAN TEMPS

MONTH	2001 AVERAGE		94-YEAR 1908-2001 AVERAGE		DEPARTURE		HIGH AVERAGE	(YEAR)	LOW AVERAGE	(YEAR)
JAN	28.29	°F	25.33	°F	2.96	°F	35.4	(1986)	7.8	(1937)
FEB	26.61		30.02		-3.41		41.1	(1954)	16.0	(1929)
MAR	36.87		36.45		0.42		45.5	(1986)	19.9	(1912)
APR	48.98		46.46		2.53		53.6	(1930)	35.9	(1920)
MAY	56.73		56.25		0.47		65.3	(1934)	48.0	(1995)
JUN	68.28		66.56		1.73		73.5	(1956)	59.1	(1945)
JUL	76.50		73.37		3.13		79.9	(1934)	67.6	(1915)
AUG	72.52		71.50		1.02		77.0	(1983)	65.3	(1927)
SEP	64.57		62.35		2.22		68.4	(1998)	53.8	(1965)
OCT	50.98		50.34		0.65		59.0	(1963)	40.7	(1969)
NOV	41.07		36.68		4.39		45.8	(1949)	23.5	(1929)
DEC	30.89		27.61		3.28		36.3	(1980)	12.7	(1983)
YEARLY AVE MEAN TEMP	50.190	°F	48.5750	°F	1.615	°F	52.64	(1934)	44.81	(1912)

ALL TEMPERATURES IN DEGREES F

2001 Date included in Averages

MAX TEMPS

TABLE 2. AVERAGE MONTHLY MAXIMUM TEMPERATURES

JAN	41.35	°F	38.05	°F	3.30	°F	49.6	(1934)	20.8	(1937)
FEB	38.11		42.82		-4.71		56.0	(1954)	28.6	(1929)
MAR	48.29		49.72		-1.43		60.6	(1972)	28.7	(1912)
APR	62.73		60.52		2.21		69.9	(1908)	45.7	(1920)
MAY	69.81		70.05		-0.24		81.9	(1934)	57.5	(1995)
JUN	83.70		81.32		2.38		89.6	(1952)	70.0	(1928)
JUL	92.13		88.79		3.34		97.6	(1934)	81.2	(1915)
AUG	88.81		86.87		1.93		93.8	(1937)	77.5	(1927)
SEP	80.47		77.99		2.48		85.8	(1998)	65.6	(1965)
OCT	66.77		65.81		0.96		75.1	(1963)	50.8	(1969)
NOV	56.10		50.39		5.71		62.2	(1949)	33.0	(1929)
DEC	44.58		40.20		4.38		51.6	(1957)	22.4	(1983)
YEARLY AVE MAX TEMP	64.404	°F	62.711	°F	1.693	°F				

MIN TEMPS

TABLE 3. AVERAGE MONTHLY MINIMUM TEMPERATURES

JAN	15.23	°F	12.61	°F	2.62	°F	22.9	(1953)	-5.3	(1937)
FEB	15.11		17.22		-2.11		26.6	(1992)	2.2	(1936)
MAR	25.45		23.17		2.28		30.9	(1986)	11.0	(1912)
APR	35.23		32.39		2.84		39.3	(1930)	26.1	(1920)
MAY	43.65		42.45		1.19		48.6	(1934)	36.5	(1917)
JUN	52.87		51.79		1.08		57.7	(1956)	46.0	(1945)
JUL	60.87		57.94		2.93		62.6	(1966)	54.1	(1915)
AUG	56.23		56.13		0.10		60.8	(1983)	52.2	(20&74)
SEP	48.67		46.71		1.96		52.6	(1963)	41.2	(12&45)
OCT	35.19		34.86		0.34		43.0	(1963)	28.9	(1917)
NOV	26.03		22.97		3.06		29.4	(1998)	14.0	(1929)
DEC	17.19		15.02		2.17		21.9	(1946)	3.1	(1983)
YEARLY AVE MIN TEMP	35.976	°F	34.439	°F	1.537	°F				

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TABLE 4. SUMMER GROWING SEASON RAINFALL, TEMPERATURE, AND GROWING DEGREE-DAY SUMMARY FOR USDA-ARS RESEARCH STATION, AKRON, COLORADO [2001 & 94-AVERAGE]

RAINFALL inches			TEMPERATURE DATA MAY-SEPT. 2001									
			AVERAGE MEAN TEMP Deg F		GROWING DEGREE-DAYS**		NUMBER OF DAYS 90 or ABOVE; 100 or Above; 55 or BELOW					
							AKRON -- 2001			AKRON 94-YR AVE		
MONTH	2001*	AVG*	2001*	AVG*	2001*	AVG*	90+	100+	<55	90+	100+	<55
MAY	3.96	2.98	56.73	56.25	252.5	236.2	0	0	31	1.0	0.0	30.4
JUN	1.32	2.46	68.28	66.56	551.0	499.9	12	1	17	7.6	0.6	21.8
JUL	2.66	2.70	76.50	73.37	821.5	724.6	21	1	2	16.1	2.0	8.7
AUG	2.26	2.10	72.52	71.50	698.0	666.7	19	0	13	13.6	0.8	13.1
SEP	1.54	1.24	64.57	62.35	443.5	388.9	9	0	26	4.9	0.1	26.5
TOTALS	**11.74**	**11.49**	**67.74**	**66.00**	**2766.5**	**2516.3**	**61**	**2**	**89**	**43.2**	**3.5**	**100.5**

* 94-year average rainfall and temperature data(1908-2001): and number of days 90 or above, 100 or above, and 55 or less; at Central Great Plains Res. Sta., Akron, Colorado

** GROWING DEG-DAYS defined as number of days with daily mean temperature above a 50-degree F base. For example..Max = 85; Min = 53; Mean = (85+53)/2=69. Deg-Day unit = 69 - 50 = 19 GDD units.

AKRON GDD UNITS ACCUMULATED FROM MAY 1 THROUGH SEPT. 30.

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TABLE 5. RAINFALL AMOUNTS BY MONTHS. USDA-ARS, AKRON, COLORADO

(Based on 8:00 am daily observation time)

2 0 0 1 RAINFALL SUMMARY

MONTH	2001 TOTAL	94-YEAR AVE AVE. 1908-2001	DEPART.	% OF AVERAGE	HIGH TOTAL	(YEAR)	LOW TOTAL	(YEAR)	2001 CUM	93-YR AV CUM	DEPART. CUM	% OF AVERAGE	MON
JAN	0.86 inches	0.34 inches	0.52	255.7%	1.51	(1988)	0.00	(6 YRS)	0.86	0.34	0.52	255.7%	JAN
FEB	0.43	0.35	0.08	123.9%	1.68	(1915)	0.00	(9 YRS)	1.29	0.68	0.61	188.7%	FEB
MAR	1.02	0.84	0.18	122.0%	3.06	(1909)	0.00	(1908)	2.31	1.52	0.79	152.0%	MAR
APR	1.32	1.65	-0.33	80.0%	5.19	(1915)	0.17	(1928)	3.63	3.17	0.46	114.5%	APR
MAY	3.96	2.98	0.98	132.8%	7.79	(1917)	0.13	(1974)	7.59	6.15	1.44	123.4%	MAY
JUN	1.32	2.46	-1.14	53.6%	6.11	(1965)	0.19	(1952)	8.91	8.61	0.30	103.4%	JUN
JUL	2.66	2.70	-0.04	98.6%	7.22	(1946)	0.31	(1934)	11.57	11.31	0.26	102.3%	JUL
AUG	2.26	2.10	0.16	107.5%	7.36	(1918)	0.16	(1973)	13.83	13.41	0.42	103.1%	AUG
SEP	1.54	1.24	0.30	123.8%	4.83	(1950)	0.00	(1978)	15.37	14.66	0.71	104.9%	SEP
OCT	0.63	0.91	-0.28	69.2%	3.71	(1993)	0.00	(3 YRS)	16.00	15.57	0.43	102.8%	OCT
NOV	0.78	0.56	0.22	139.8%	2.67	(1946)	0.00	(3 YRS)	16.78	16.12	0.66	104.1%	NOV
DEC	0.00	0.41	-0.41	0.0%	3.27	(1913)	0.00	('08,28,'02)	16.78	16.53	0.25	101.5%	DEC
Total	16.78 inches	16.5306 inches	0.25	101.5%	26.79	(1946)	9.93	(1939,74)	16.78	16.53	0.25	101.5%	

LAST UPDATE>> 31-Dec-2001 < * thru this date

2001 Final -- 2001 data included in average

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Table 6. Snowfall Dates and Depths for Calendar Year 2001
USDA-ARS Research Station, Akron, Colorado

DATE	Snow Depth inches		Precipitation inches
Jan 14 -- Jan 19	2.50		0.13
Jan 26 -- Jan 30	10.00		0.73
Feb 8 -- Feb 9	Trace		Trace
Feb 11	Trace		Trace
Feb 13 -- Feb 14	1.00		0.02
Feb 16	Trace		Trace
Feb 21	Trace	ice/fog	Trace
Feb 23 -- 25	4.00		0.11
Feb 27 -- 28	10.00		0.30
Mar 11 -- 12	12.00		0.70
Mar 16	1.50		0.15
Mar 18	Trace		Trace
Mar 22	Trace		0.02
Mar 26	Trace		0.05
Mar 31	1.00		0.10
Apr 11-12	10.00		0.70
Apr 21-23	6.00		0.58
21-May	1.00		0.12
Sub-Total	**59.00**		**3.71**
Oct 5	Trace		0.10
Oct 15	Trace		0.37
Nov 8	1.00		0.05
Nov 19	Trace		Trace
Nov 25-26	8.00		0.35
Sub-Total	**9.00**		**0.87**
TOTALS	**68.00**		**4.58**

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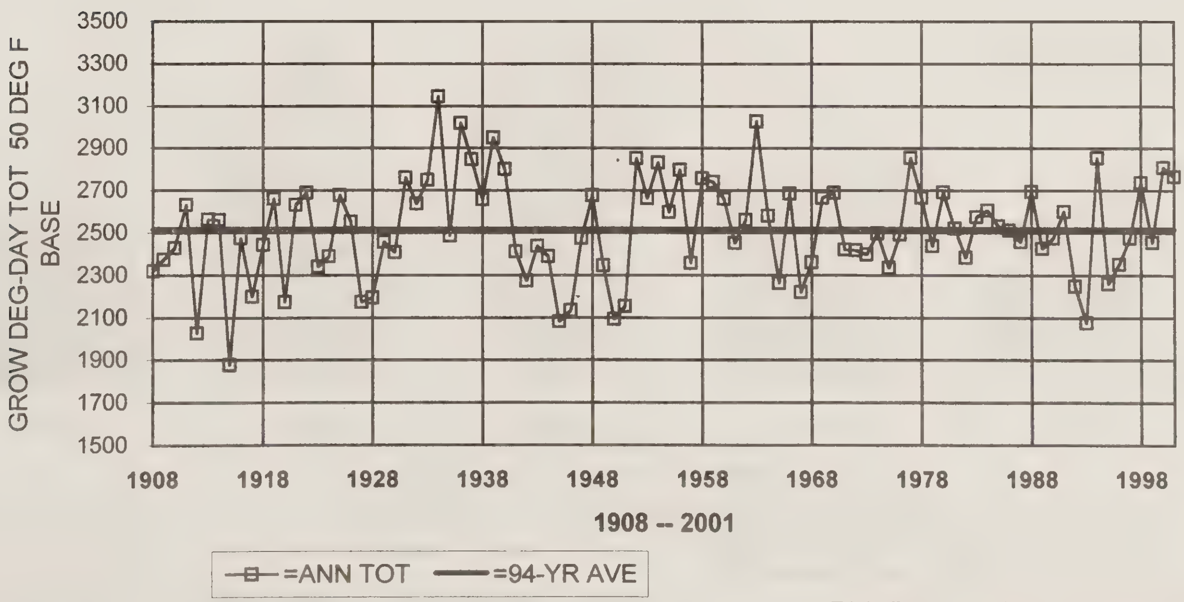
GROWING DEGREE-DAYS (MAY-SEPT)
USDA-ARS RESEARCH STATION, AKRON, CO



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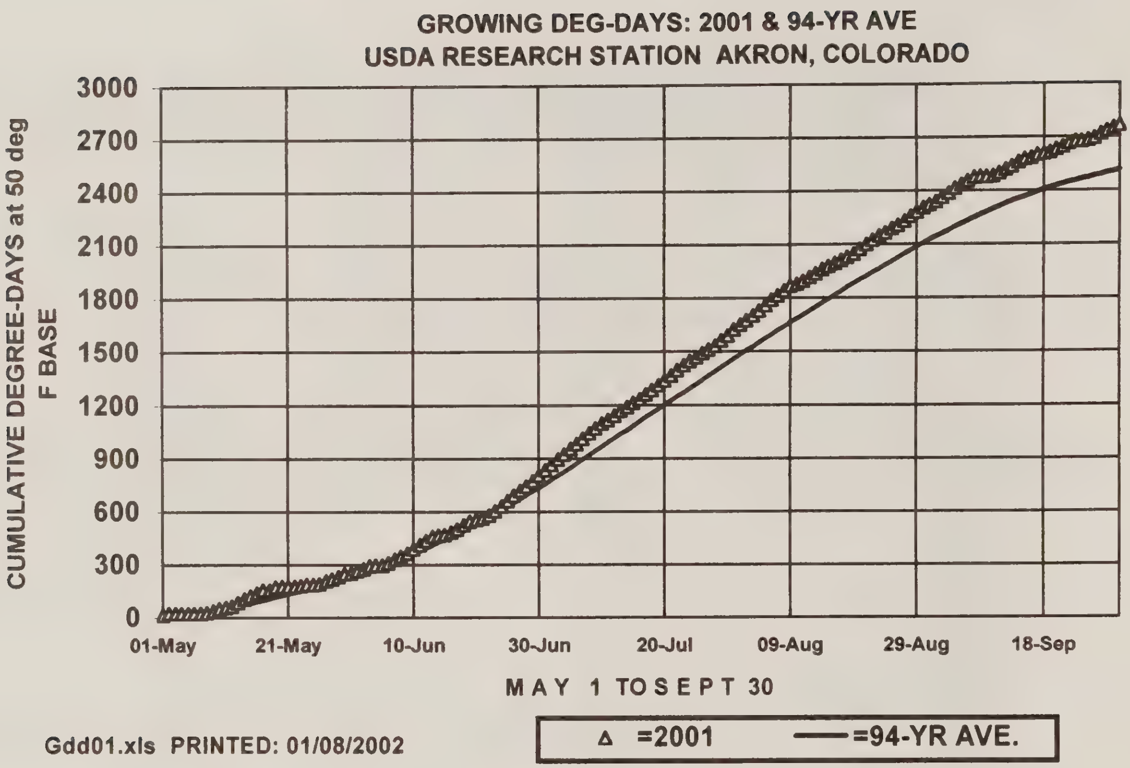
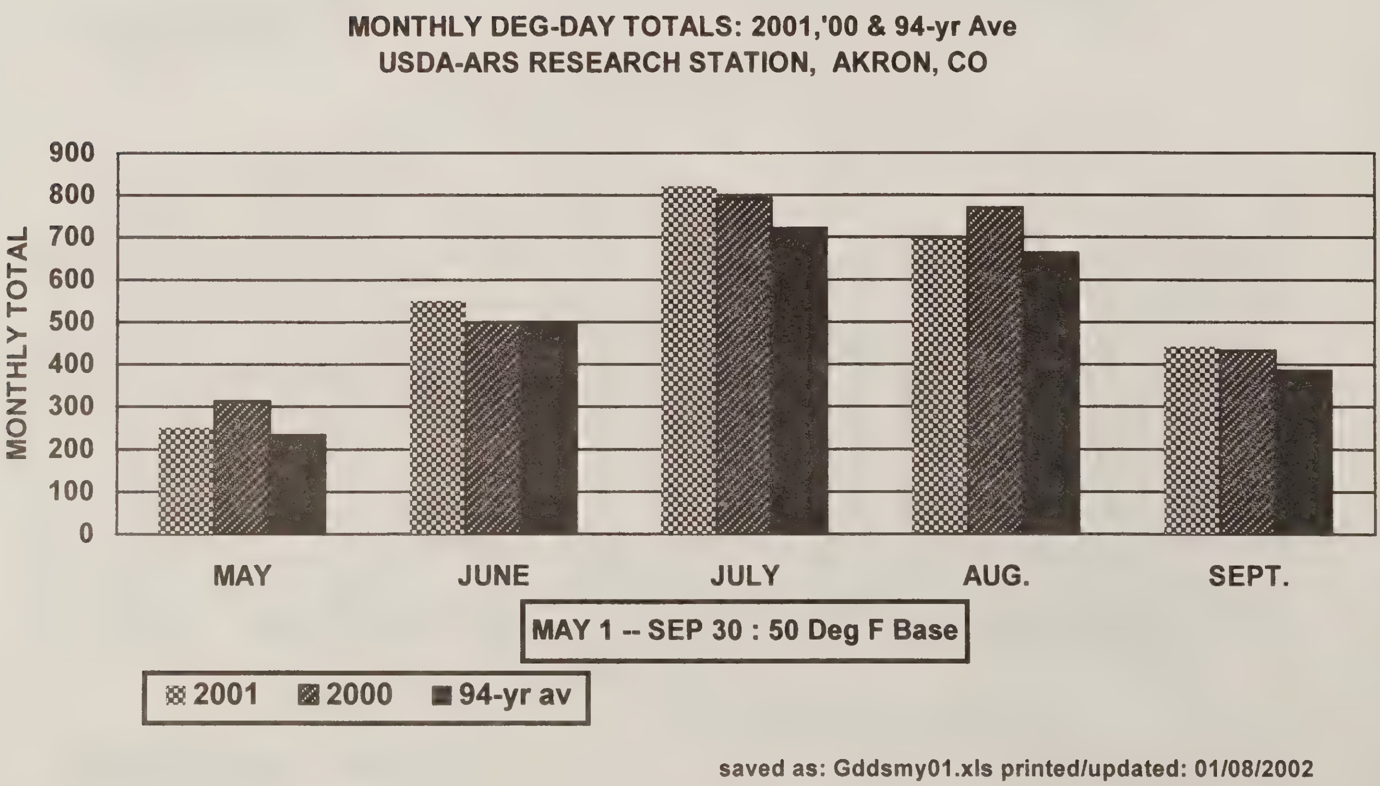

GROWING DEG-DAYS: 2001 & 94-YR AVE
USDA RESEARCH STATION AKRON, COLORADO
CUMULATIVE DEGREE-DAYS at 50 deg F BASE
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
01-May
21-May
10-Jun
30-Jun
20-Jul
09-Aug
29-Aug
18-Sep
M A Y 1 TO S E P T 30
Gdd01.xls PRINTED: 01/08/2002
=2001
=94-YR AVE.


MONTHLY DEG-DAY TOTALS: 2001,'00 & 94-yr Ave
USDA-ARS RESEARCH STATION, AKRON, CO
MONTHLY TOTAL
900
800
700
600
500
400
300
200
100
0
MAY
JUNE
JULY
AUG.
SEPT.
MAY 1 -- SEP 30 : 50 Deg F Base
2001
2000
94-yr av
saved as: Gddsmy01.xls printed/updated: 01/08/2002

2001 RAINFALL

CENTRAL GREAT PLAINS RESEARCH STATION AKRON, COLORADO

PRECIPITATION LOG 2001 STANDARD GUAGE inches LOCATION: WEATHER STATION

[Rainfall amounts are for the period 12:00 midnight to 12:00 midnight for the date recorded.]

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1								1.40		T			1
2					0.02	0.22	0.03	0.11					2
3					0.22	0.05							3
4				T	0.71	0.09	0.03			T			4
5					1.45					0.10			5
6				0.04				0.14	0.09	T			6
7						0.35			0.30		0.10		7
8						0.04			0.41		0.05		8
9		T					0.06			0.16			9
10			0.45	0.18			0.63						10
11		T	0.25	0.52			0.08						11
12							0.35						12
13	0.10	0.02				0.49		0.47					13
14									0.14	0.05			14
15		T	0.15						0.51	0.32			15
16	0.03							0.05	T				16
17	T		T		T				0.06				17
18													18
19											T		19
20				0.08	0.12								20
21		T		T				0.03					21
22			0.02	0.25				0.03					22
23				0.25			0.92				0.28		23
24		0.11					0.06						24
25			0.05				0.50						25
26					0.04						0.35		26
27	0.30	0.30			0.02	0.08							27
28	0.28				0.40								28
29	0.07				0.98								29
30	0.08												30
31			0.10				0.03	0.03					31

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
SUM	0.86	0.43	1.02	1.32	3.96	1.32	2.69	2.26	1.51	0.63	0.78	0.00	MONTHLY TOTAL
AVE	0.34	0.35	0.84	1.65	2.98	2.46	2.70	2.10	1.24	0.91	0.56	0.41	<<94-YEAR AVE
DEP	0.52	0.08	0.18	-0.33	0.98	-1.14	-0.01	0.16	0.27	-0.28	0.22	-0.41	DEPARTURE
%NORM	255.7%	123.9%	122.0%	80.0%	132.8%	53.6%	99.7%	107.5%	121.5%	69.2%	139.8%	0.0%	MONTHLY % OF NORMAL
CUM	0.86	1.29	2.31	3.63	7.59	8.91	11.60	13.86	15.37	16.00	16.78	16.78	CURRENT ACUM
AVCM	0.34	0.68	1.52	3.17	6.15	8.61	11.31	13.41	14.66	15.57	16.12	16.53	AVE ACUM
DEP	0.52	0.61	0.79	0.46	1.44	0.30	0.29	0.45	0.71	0.43	0.66	0.25	DEPARTURE
%of NORM	255.7%	188.7%	152.0%	114.5%	123.4%	103.4%	102.5%	103.3%	104.9%	102.8%	104.1%	101.5%	CUM % OF NORM

LAST UPDATE>> 08-Jan-02

Final 2001

NOTE: NEW MONTHLY AVERAGE IS CALCULATED.......NEW AVERAGE INCLUDES 2001 RAINFALL DATA

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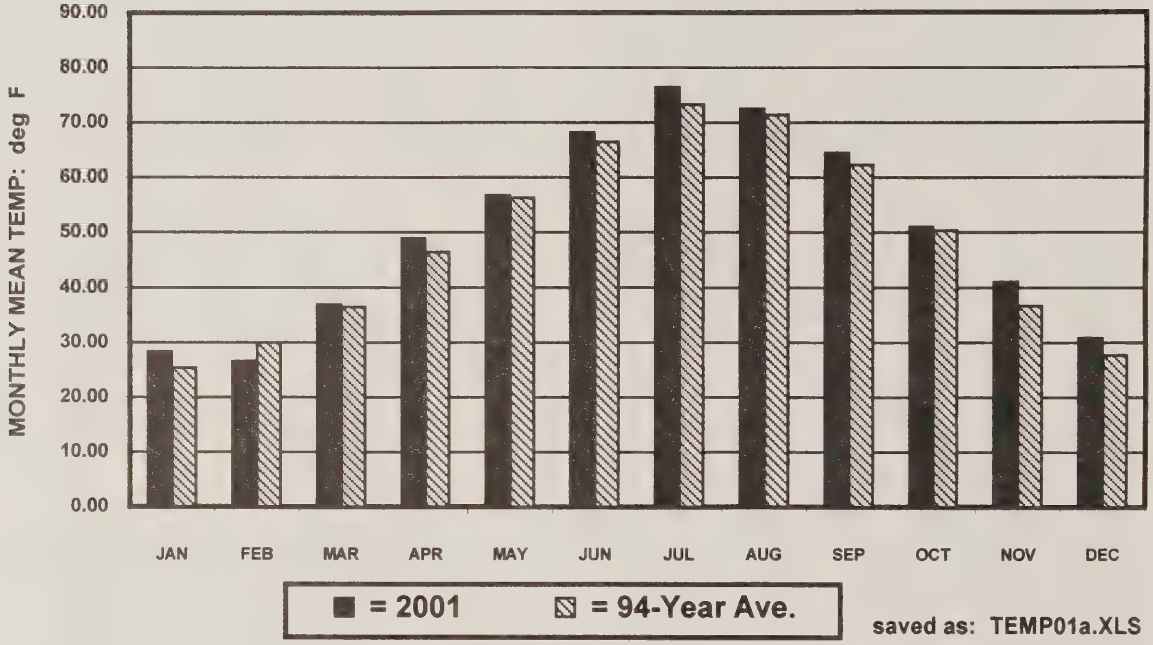
MONTHLY MEAN TEMP: 2001 & 94-YEAR AVE
USDA-ARS AKRON, COLORADO



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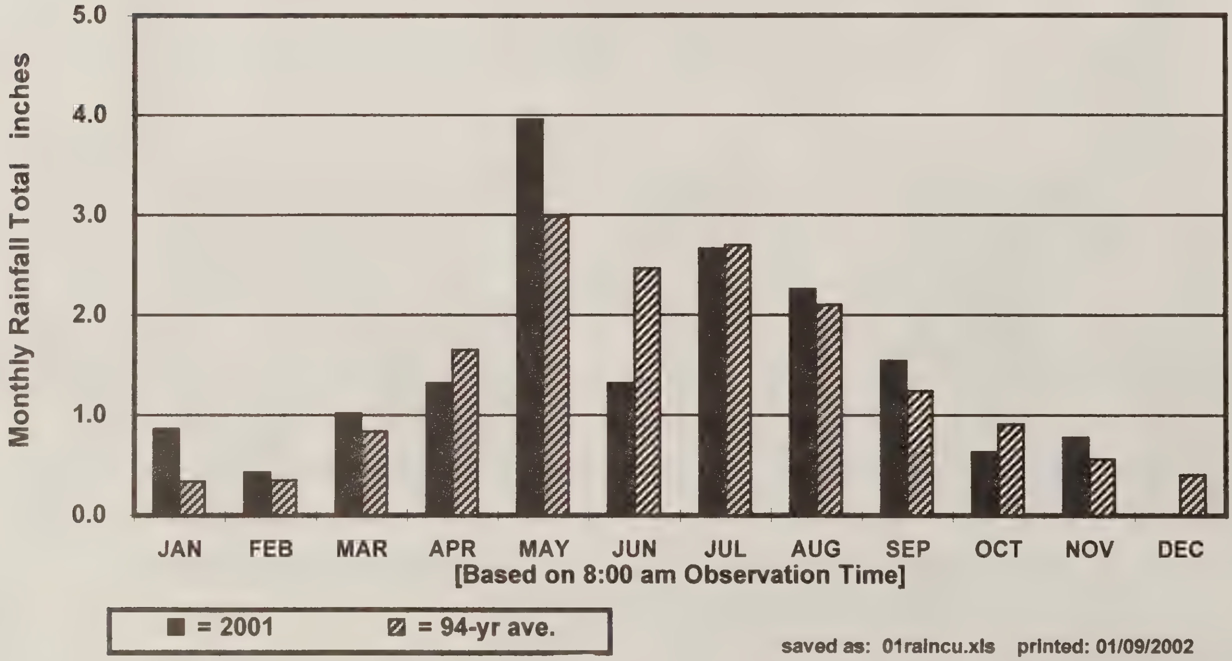
MONTHLY RAINFALL TOTAL 2001 & 94-Yr Ave inches
USDA-ARS RESEARCH STATION Akron, Colorado



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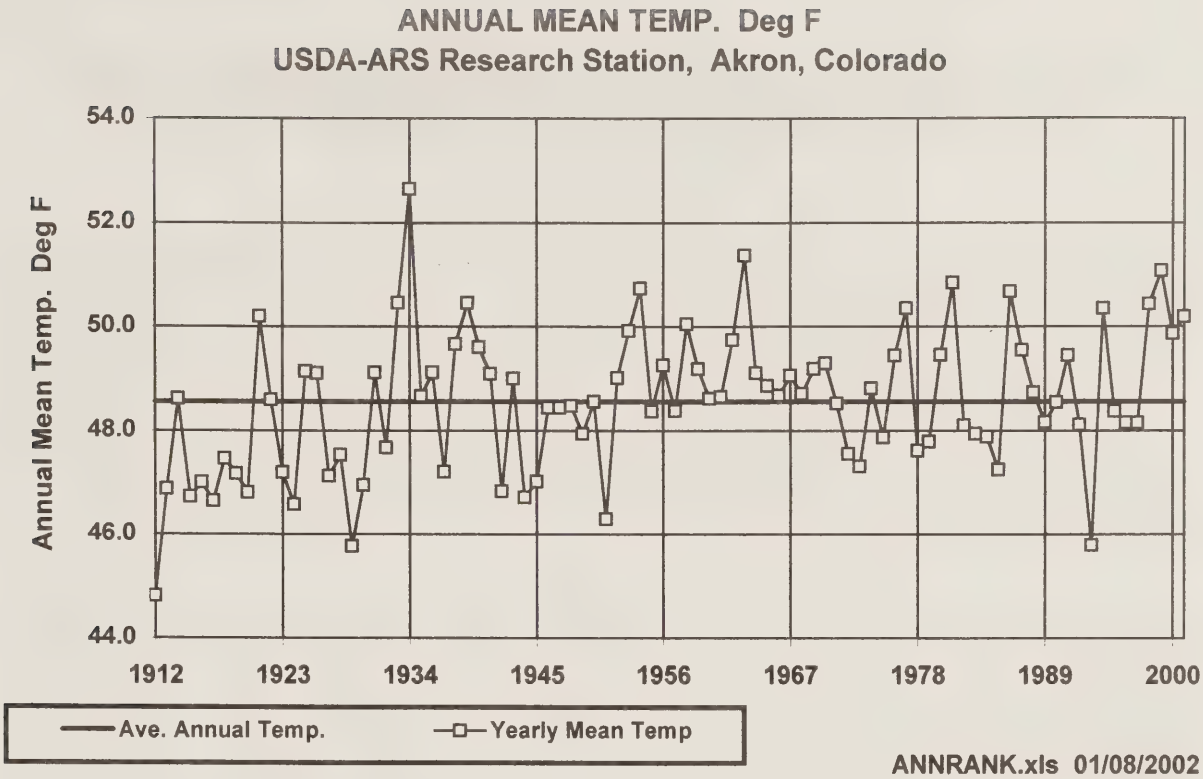
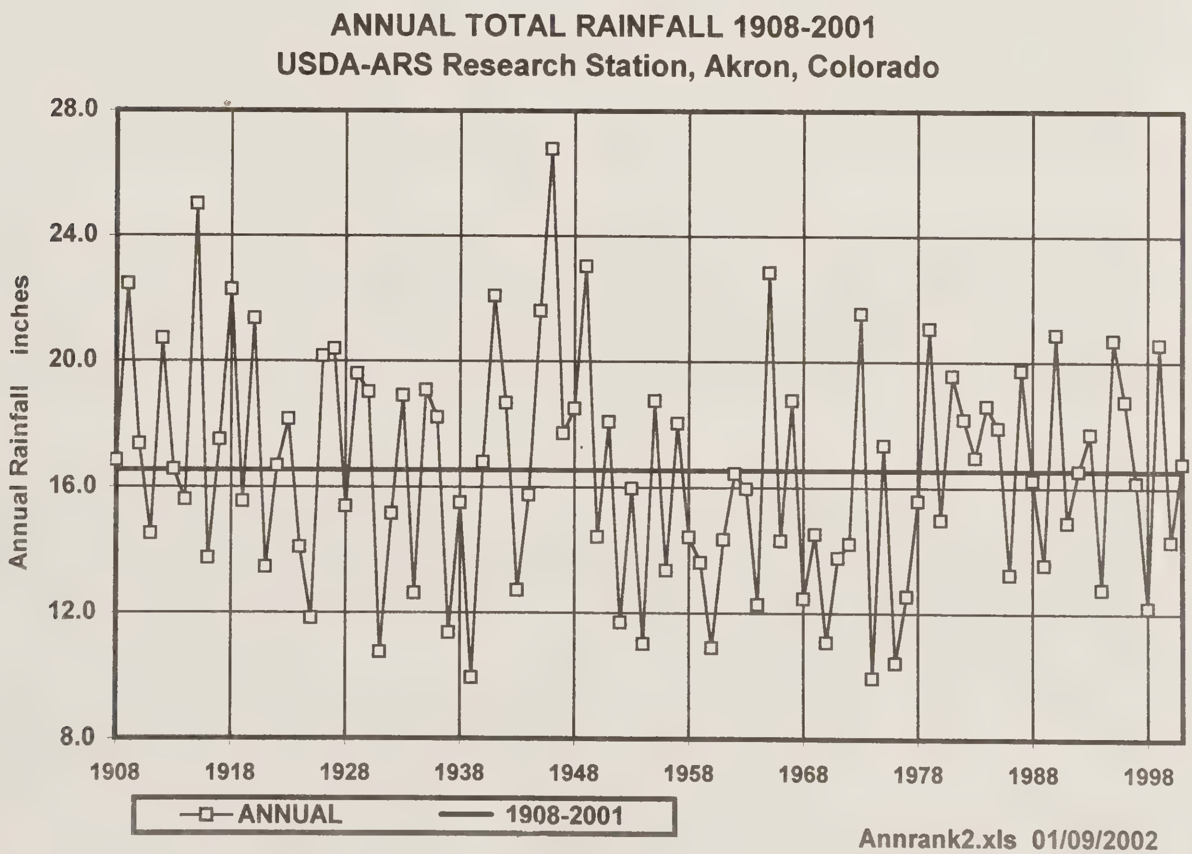


ANNUAL MEAN TEMP. Deg F
USDA-ARS Research Station, Akron, Colorado
Annual Mean Temp. Deg F
54.0
52.0
50.0
48.0
46.0
44.0
1912
1923
1934
1945
1956
1967
1978
1989
2000
Ave. Annual Temp.
Yearly Mean Temp
ANNRANK.xls 01/08/2002



ANNUAL TOTAL RAINFALL 1908-2001
USDA-ARS Research Station, Akron, Colorado
Annual Rainfall inches
28.0
24.0
20.0
16.0
12.0
8.0
1908
1918
1928
1938
1948
1958
1968
1978
1988
1998
ANNUAL
1908-2001
Annrank2.xls 01/09/2002

EVALUATING SOIL ENVIRONMENT EFFECTS ON ROOT GROWTH FOR SELECTED LEGUMES GROWN IN THE CENTRAL GREAT PLAINS

J.G. Benjamin, D.C. Nielsen

PROBLEM: In recent years crop rotations in the central Great Plains have changed from wheat-fallow to wheat-(summer crop[s])-(fallow). The summer crop[s] have included combinations of various crops such as corn, proso millet for grain, foxtail millet for forage, and/or sunflower for various numbers of years. These rotations may or may not include a fallow period before planting back into wheat. Discussions with farmers in the area have shown the need for an economical legume species to be included in the rotations. Likely candidates for suitable legume species include soybean (either for seed or for forage), garbanzo bean and field pea. Little is known about the water requirements for these species in the semi-arid west, or how the species respond to water stress or other soil environmental factors.

APPROACH: We continued an experiment to examine root growth of garbanzo bean, soybean and field pea under two water regimes in 2001. The two water regimes include the natural rainfall condition and a fully watered condition controlled by supplemental irrigation. Soil samples for root biomass of each species were collected at two times during the growing season, once at about the maximum of vegetative growth and once after flowering during seed set. The samples were collected in 9" (22.5 cm) depth intervals to a depth of 45" (112.5 cm) with a 3" (7.5 cm) diameter sampling tube directly beneath a plant. Three sub samples were taken for each site. There were three replications. The soil samples were weighed in the field and a moisture sample was removed for moisture and bulk density determination. The samples were washed to extract the roots with a semi-automatic root washing apparatus. The root samples were preserved in methanol until time for determination of length, area, and dry weight. Root sample length and area are being determined from a scan of a digital image using Sigma Scan image analysis software.

RESULTS: We are in the process of analyzing the root images. Results will be expressed in terms of total root length per unit area, root length density with depth and root mass per unit length. Combined with above-ground sampling already being taken, estimates of root/shoot ratios can be calculated. The moisture content and bulk density information will be used to calculate the least limiting water content range (a measure of soil physical quality) for the soil. We will then be able to evaluate root patterns for the different species as affected by the rooting environment.

FUTURE PLANS: We continue to analyze the root samples collected in 2001. Procedures are being developed to speed the analysis of the root samples and the separation of root material from crop residue. We hope to identify differences in rooting patterns among species in response to available water conditions. This information may help us identify species suited to the severe climate of the central Great Plains.

USING LIMITED IRRIGATION FOR CROP PRODUCTION IN THE CENTRAL GREAT PLAINS

J.G. Benjamin, D.C. Nielsen, M.F. Vigil

PROBLEM: Irrigation water supplies in the central Great Plains of the United States continue to diminish due to use by farmers and additional demands for these water resources by urban areas. We envision that farmers will have less water available for irrigation in the future. Water resources need to be managed such that we maximize production for each unit of irrigation water. It is well recognized there are critical periods during a crop's life cycle where minimizing water stress results in maximum yield. Several researchers have proposed limiting the application of irrigation water to these periods. Less in known about the long-term effects of limited irrigation on soil productivity and the sustainability of limited irrigation systems.

APPROACH: We modified a study of soil compaction effects on corn (*Zea mays*, L.) growth and soil biological activity at Akron, Colorado, on a Weld silt loam (fine smectic, mesic Aridic Paleustolls) that was started in 1997. We continued the tillage treatments of the previous experiment by tilling the appropriate plots to a 12 inch depth in the fall of 2000. The other plots continued to have no-till management as they have since 1997. We added a crop rotation to the experiment with one half of the field in a corn-dry bean(2001)-barley-sunflower rotation and the other half of the field remaining in continuous corn. The field was planted in the spring and plant growth characteristics for corn and dry bean were measured throughout the growing season. An irrigation treatment was imposed on the rotations with half the field receiving full irrigation as determined from ET estimates and the other half of the field receiving no irrigation until the crop started to flower. After flowering the entire field received full irrigation based on estimated ET. We harvested the plots in the fall and determined yield and biomass. We collected soil samples in the fall after harvest to determine changes in the soil bulk density caused by tillage and crop rotation.

RESULTS: The irrigation treatment had a significant effect on plant biomass for both corn and dry bean. Biomass production for the delayed irrigation plots was about 70% of the fully irrigated plots for both corn and bean. Seed yield was not significantly different between fully irrigated or delayed irrigated plots for either corn or bean. We used about 50% of the water for the delayed irrigated plots (7 inches of irrigation water) compared with the fully irrigated plots (13.5 inches of irrigation water). The experiment shows that, in the initial year of a delayed irrigation schedule, comparable yields are possible with a great savings of irrigation water. Tillage had no significant effect on either biomass or seed yield with either irrigation system.

FUTURE PLANS: We will continue the experiment in 2002. The crops planted will be corn in the continuous corn plots and barley in the crop rotation plots. We will install neutron access tubes in each plot to better evaluate water stress and irrigation efficiency. Other measurements of crop emergence, LAI, biomass, yield, and soil properties will remain the same. We are particularly interested in the cumulative effects of partial irrigation on the early plant growth when the current crop is planted on a soil depleted of water by the previous crop.

SOIL ORGANIC CARBON SPATIAL VARIABILITY AND CARBON SEQUESTRATION

R.A. Bowman, J.D. Reeder[1], B.J. Wienhold[2]

PROBLEM: Reliable quantification of soil organic carbon (SOC) is necessary if we are to reward good stewardship and conservation through carbon credits, and to assess our potential to meet the conditions of the **Kyoto Protocol** (7% reduction from 1990 levels of greenhouse gases between 2008 and 2012). Besides the benefits of reducing erosion and conserving water through adequate crop residue production and management (no-till practices, increasing the cropping intensity, adequate fertilization), SOC has been estimated to have a realistic value of $10 to $20/ton ($5 to $10/acre). To arrive at such benefits, we need an agreed upon methodology for determining verifiable changes in SOC stock (levels). Essentially, we need to know, given laboratory and field spatial variability for SOC and bulk densities measurements:

"What are the existing carbon levels and how small a change over time can be measured"
Such changes can be assessed with time for the same treatment (rotation), or in time where different treatments are compared.

APPROACH: To address these questions we conducted research to evaluate differences in SOC concentration at three different laboratories (Akron, Cheyenne, and Lincoln) from: 1) same samples, 2) spatial variability of a common treatment rotation (replicates of the same treatment), and 3) changes from five different rotations (treatment variability) compared to the traditional winter wheat-fallow (W-F) rotation, and to the existing adjacent native sod.

RESULTS: All three laboratories showed good reproducibility from the same set of samples with CVs less than 5%. Means for the three laboratories were not significantly different. At the Akron lab we also compared the standard C-N Analyzer procedure with the Walkley-Black (chromic acid) and Loss-on-ignition (furnace at 400C) procedures. All three methods showed good correspondence but the C-N Analyzer overestimated SOC in calcareous soils. Spatial variability was very significant, but we were still able to obtain SOC treatment differences among rotations (WF, WCF, WSunF, WCMF, WCSunF, WCM). Data (corrected for bulk densities) showed that SOC content (volumetric basic to 6 inches) for WF and WSunF were the same, and that there were no differences among rotations with fallow. WCM (no fallow) was the same as rotations with fallow of 3- or 4-year duration. SOC content followed the following numerical order

WCM > WCMF > WCF > WCSunF > WSunF > WF

CONCLUSIONS: Present methodologies are capable of adequately quantifying SOC stocks, and changes that might occur because of treatment effects. It does appear, however, that the treatments may have to be widely different under relatively short time frame (< 10 years) for significant changes to be detected. These results were written up for publication, and will be published in 2002 in **Communications in Soil Science and Plant Analysis**.

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PHOSPHORUS POOLS AND AVAILABILITY IN SEMIARID SOILS

R.A. Bowman, M.F. Vigil

PROBLEM: Phosphorus is the second most important soil element for plant growth. Many areas within the Great Plains are deficient in P, so its excess and waste have never been a concern. A serious problem within the Great Plains, though, is soil erosion, and secondarily, its association with P. This problem is magnified when eroded P enters surface waters and cause eutrofication. This concern, however, is attenuated by the fact that, generally, P loading in our soils is minimal, and consequently, its removal and discharge into surface waters do not present a serious problem. The situation may change, however, with the advent of large containment areas (concentrated animal feeding operations, CAFO), and the need to use and dispose of animal waste and the excess P generated by these large CAFO units. For this reason many states are developing a **Phosphorus Index** to facilitate managing P so as not to cause adverse effects on the environment

APPROACH: A need exists, therefore, to assess the potential of these relatively low-P soils to fix and release all forms of P (fertilizers and manures) , and how this fixation (P saturation) might correlate to the soil test **"available P"** which is the form that is routinely determined. We assessed the P adsorption capacity (P saturation), P buffering capacity (tendency to release or hold P because of reacting surfaces in texture and organic matter), and the soil test P values for the same soils. Manure samples were also assessed for these parameters.

RESULTS: Manure P was not as available as chemical fertilizer P because of interaction with Ca and Mg and other salts in the manures. Thus manure for P adsorption was higher than for the same quantity of fertilizer P. Calcium carbonate eroded soils sorbed the greatest quantity of P. These P adsorption data are important since soil test P does not reflect capacity or tendency to adsorb P.

CONCLUSIONS: We prepared a review paper with data from the current literature and some data from the Akron Station in which we detailed the various P pools, how these pools are measured, and their interactions and relationships with soil testing P. The manuscript is submitted to the Journal of Soil and Water Conservation.

SOIL ORGANIC MATTER CHANGES UNDER ALTERNATE CROPPING AND TILLAGE SYSTEMS

R.A. Bowman, M.F. Vigil, D.C. Nielsen, J.G. Benjamin

PROBLEM: Soil organic matter (SOM) is important to hold the soil together, to easily infiltrate water, to reduce compaction, and to provide nutrients such as N, P, K, S, and micronutrients. However, the conversion of Great Plains grassland to clean-till small grain farmlands since the mid 19^{th} century has resulted in extensive loss of the native SOM because of wind erosion and decomposition. On a global basis with about 40% more organic carbon residing in the SOM than in the terrestrial plant biomass, it is easy to see how the conversion of grassland to wheat-fallow could create over time a drop in crop production and a significant increase in global CO_2. On the other hand, if we intensify the cropping system over the WF, and minimize soil disturbance through less tillage, and if we manage water, fertilizer, and pests efficiently, we should be able to reverse SOM loss and increase soil productivity. Our objective, therefore, was to evaluate different cropping systems for their efficiency in water and nutrient use, minimal soil erosion, minimal chemical leaching, and organic matter buildup. This report focuses on changes in SOM.

APPROACH: The study is located at Akron, CO on a predominantly Weld silt loam. Three replications of 60 combinations and permutations of cropping and rotation sequences exist (See report by Anderson, Nielsen, Bowman, and Vigil for treatments). Extensive sampling was conducted on all 180 sites for soluble (dichromate oxidation) and total SOM and POM and total organic C and N (C-N analyzer). Soil samples were collected at 0-2 inch, and at 2-6 inch depths for pH and nutrient stratification and for plow layer evaluations especially under the no-till conditions and mixing under conventional-till. Soil samples on different soil series were taken to 5 feet depth. Analyses were also made on 0-6 and 6-12 inch depths.

RESULTS: New data showed the same past trends with more intensively cropped rotations with less fallow having more SOM content. Since a paper on SOM matter changes has already been written other data relevant to chemical changes due to cropping intensity were left with the Unit. These data for the 40 blocked sites (4 cropping intensities x 5 blocks x 2 reps) include: pH, excess CEC, base saturation, lime, soluble salts, nitrates, available P, K, S, Zn, Ca, Mg, Na, Fe, Mn, Cu, B, along with particle size distribution.

EFFECT OF CULTIVATION ON PHOSPHOROUS COMPARTMENTALIZATION DYNAMICS AND TRANSPORT IN COARSER SANDY SOILS

J.A. Delgado, R.A. Bowman[1], R. Sparks[2]

PROBLEM: There are several factors that affect P availability including pH, soil texture organic matter, and addition of organic manures. Although average P use efficiency has been reported to be about 10%, P fertilization is needed and important for maximizing yields. It is important to use best management practices that reduce the offsite transport of P, decreasing the potential eutrophication impacts of P on water bodies. It is important to understand how management practices and crop rotations affect phosphorous pools and their dynamics.

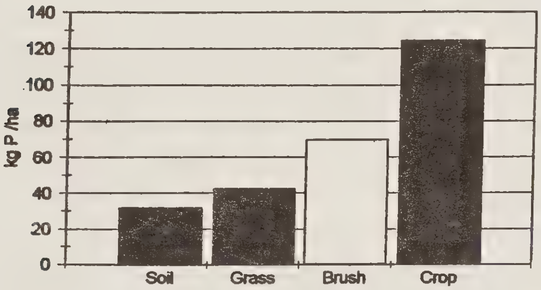

Figure 1 P content of native soil, grass, brush and crop sites

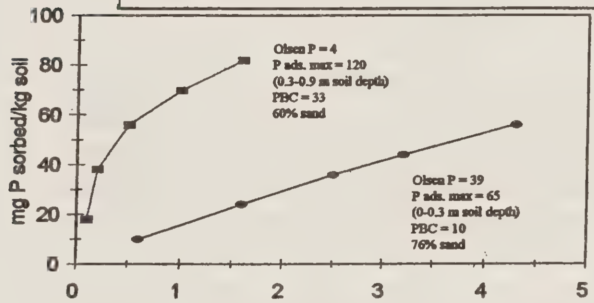

Figure 1 Absorption isotherms for different soil depths

APPROACH: We collected soil samples in several cultivated and native sites of the San Luis valley. Four fields were sampled collecting at the sandy loam and loamy sand areas at 0.3 m intervals down to 0.9 m depths. For these four fields samples were collected in 1996 (about 20 years of cultivation) and again in 2001 (about 25 years of cultivation). Samples were also collected at a native non-cultivated site (0 years of cultivation). Additionally, we sampled the surface 0.3 m of cultivated soil from ten different fields with a paired sample collected at the non cultivated native sites. Plant samples were collected at harvest and P uptake by crops grown at these different sites was measured. Adsorption isotherms were also determined on these cultivated and non cultivated soil samples. To construct these isotherms, sixteen-hour equilibrations were carried out with 5 g soil to 50 mL 0.01 M $CaCl_2$. At all of these sites we measured the $NaHCO_3$ extractable P (Olsen method), the acid extractable inorganic P, the acid extractable organic P, and the resin P pools. The CSU method of AB-DTPA was also used for some samples.

RESULTS: The concentrations of P after two decades of cultivation has significantly increased, and doubled in the cultivated sites.

Future Plans: Final analyses for all the isotherms and the compartmentalization of P in different soil pools will be conducted. A manuscript with these results will be published.

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RISK AND RETURNS FOR ALTERNATIVE DRYLAND CROP ROTATIONS IN THE CENTRAL GREAT PLAINS

D.A. Kaan, P.A. Burgener, D.M. O'Brien

Problem: In recent years the number of acres in fallow has decreased in the region as crop production methods and United States agricultural policy have encouraged increased acres planted to alternative crops. The number of acres planted to sunflowers, proso millet, corn and other crops has increased dramatically, while the number of acres of wheat has not decreased proportionately. This study will evaluate the profitability of these intensive cropping systems.

Approach: Yield data collected at the USDA-ARS Central Great Plains Research Station (CGPRS) from 1994 through 2000 has been utilized for this analysis. Price received and cost of production data have been utilized from USDA and Colorado State University sources. Rainfall and temperature data was collected at CGPRS. Each cropping system was allowed to complete one full cycle to allow for synergistic affects of the entire crop rotation.

Ordinary least squares regression was used to develop crop response models used for estimation of yield based on rainfall, temperature and the effect of fallow on wheat yield. The crop response models in conjunction with the price series for each crop are used to develop the returns for each crop in the system. Following a determination of the proper distribution of the data series, a Monte Carlo simulation was completed using @Risk risk analysis software.

Results: Although each of the rotations analyzed has a positive return to land and management, the more important issue is the percentage of years each rotation can be expected to be profitable. Traditionally, cropping systems are evaluated based on the average expected return with little consideration given to potential deviation from that average. Although a system may show higher average return, the variation from highest to lowest possible returns may be unacceptable to some producers.

Using this type of analysis, the preferred rotation from an average profitability and risk aversion perspective is Wheat – Millet – Fallow. This system has the highest average return and the most years meeting profitability goals. The two most variable systems, and thus the most risky, are the Wheat – Millet and Wheat – Corn – Millet. These two rotations have very large differences from highest to lowest returns and both reach breakeven ($0.00) only approximately 80 percent of the time.

Future Plans: With the baseline risk preferences demonstrated to date, the next logical step will be to evaluate the potential of risk mitigation systems. An evaluation of the effect of agricultural policy, marketing strategies and crop insurance alternatives on cropping system net returns will be beneficial for producers in the Central Great Plains.

EFFECTS OF CROPPING ROTATIONS ON BENEFICIAL AND PEST INSECTS AT THE CENTRAL GREAT PLAINS RESEARCH STATION; AKRON, CO

M.D. Koch, F.B. Peairs, G.A. Peterson

PROBLEM: In 1986 the Russian wheat aphid (RWA) became a major small grains pest in Colorado. Control methods for this pest include cultural, mechanical, chemical, and biological. Russian wheat aphid control has been most effective using chemicals. However, producers may be able to combine cultural and biological techniques to decrease the need for other costly control measures. This would also diversify production on a given farm. Crops grown in close proximity to one another providing a year-long host of green vegetation may allow predators and parasites to survive and control pests. To test this theory, plots were established at three locations in eastern Colorado. Locations are near Briggsdale, Akron and Lamar.

APPROACH: The Akron, Colorado site was established in the spring of 1996. The previous crop was corn with a small area used for sunflowers. Crops being studied were selected by area production practices. The rotations being analyzed are: winter wheat-fallow; winter wheat-corn-fallow; winter wheat-corn-millet; and winter wheat-corn-sunflower-fallow. The individual plots for this location are relatively large at 90 feet wide by 180 feet in length. Experimental layout was in a complete randomized block with four replications. Every phase of the rotations is present each year in all four replicates. The wheat plots are divided in half lengthwise. One half is a susceptible variety and the other resistant to the Russian wheat aphid *Diuraphis noxia* (Mordvilko). The varieties used for 2001 were TAM 107 as the susceptible and Prairie Red as the resistant.
WHEAT: Planting date was 13 October 2000 with a John Deere 750 no-till drill. Planting rate was 60 pounds per acre. Fertilizer applied at planting in a band two inches above and to the side of the seed was 32-0-0 liquid. Dry 11-52-0 also applied at planting was placed in the seed furrow. Rates were 42.5 pounds of nitrogen and 15 pounds of phosphorus. No-till plots were treated with Roundup Ultra *Glyphosate* at 32 ounces per acre prior to planting on 13 September. Conventionally tilled wheat-fallow plots were worked with a tandem disc on 11 September. All plots were treated with three ounces of Clarity *Diglycolamine salt* and six ounces of 2-4,D *Dichlorophenoxyacetic acid* on 01 May 2001 to kill Tansy mustard *Descurainia pinnata* (Walt.) and Kochia *Kochia scoparia* (L.).
CORN: Planting date was 19 May 2001 using a John Deere max-emerge planter. The planter was six rows wide and delivered 16,600 seeds per acre on 30 inches of spacing between rows. The variety used was Dekalb DK5333RR. Fertilizer was applied at planting using 97 pounds of nitrogen and 15 pounds of phosphorus per acre. Formulations were liquid 32-0-0, banded two inches above and to the side of the seed, and 10-34-0 which was dribbled over the seed furrow. A Roundup Ready corn variety was selected due to a Field sandbur *Cenchrus incertus* problem in the plot area prior to the establishment of this study. An application of Roundup Ultra RT *Glyphosate* at one quart per acre was used on 18 May to clean up the plots prior to planting. Another application of the same herbicide at one quart was necessary to keep the plots relatively weed free. This was accomplished using a Red-Ball covered row sprayer on 06 June.

MILLET: Sunup proso millet was planted 15 June 2001 using a John Deere 750 no-till drill with a 7.5 inch row spacing. Twenty-two pounds of nitrogen and eight pounds of phosphorus were applied at planting. The liquid 32-0-0 and dry 11-52-0 were applied in the seed furrow with 15 pounds per acre of seed. An application of one quart Roundup Original *Glyphosate* on 13 September 2000, 17 May 2001 and another 09 June cleaned up the plots.
SUNFLOWERS: Sunflowers were planted 09 June 2001 using a six-row John Deere max-emerge planter. Row spacing was 30 inches. Triumph 765 was the variety used. Fertility was enhanced with 40 pounds of nitrogen and 15 pounds of phosphorus. The fertilizers used were liquid 32-0-0, banded two inches above and to the side of the seed, and 10-34-0 which was dribbled over the seed furrow. An application of Roundup Ultra RT *Glyphosate* at one quart per acre on 18 May cleaned the plots for preparation to plant. Then an application of Spartan *Sulfentrazone* at 2 ounces per acre and Prowl *Pendimethalin* at 38 ounces per acre was applied on 09 June. Weed control was very good. However, there was approximately a 30% stand loss attributed to the use of the Spartan. Soil pH in the plots was measured with a Hach Chemicals field test kit and resulted in a 7.2 to 7.3 reading. Slightly higher than expected and high enough to cause slight damage to the sunflower stand.
FALLOWS: All fallow plots were treated as no-till except the winter wheat-fallow rotation which was conventionally tilled. Roundup *Glyphosate* or the generic and slightly cheaper version Glyphomax was used to control weeds in the no-till plots when needed. Applications of herbicide were made on 13 September 2000, 17 May 2001, 27 June, and 24 September. Each application of Roundup was made with a Tyler Patriot sprayer at 10 gallons of mix per acre. The conventionally tilled plots were tandem disced on 12 September 2000 and sweep plowed with treaders on 01 May 2001, 24 May, 14 August and finally 24 September.

Table 1. Crop, variety, seeding rate, nitrogen rate and planting date for 2001 season.

Crop	Variety	Seeding rate	N rate	Planting date
Wheat	TAM 107	60 lbs/A	42.5 lbs/A	13 Oct. 2000
Wheat	Prairie Red	60 lbs/A	42.5 lbs/A	13 Oct. 2000
Corn	DK5333RR	16.6K seeds/A	97 lbs/A	19 May 2001
Sunflowers	Triumph 765	16.6K seeds/A	40 lbs/A	09 June 2001
Millet	Sunup	15 lbs/A	22 lbs/A	15 June 2001

RESULTS - AGRONOMIC DATA

CLIMATIC CONDITIONS AFFECTING THE 2000-2001 GROWING SEASON:

Precipitation was good for all crops this past year. Moisture was received throughout the growing seasons. Corn yields were below average due to the wet conditions up until seed filling. Then the weather turned hot and dry. No notable precipitation was received between the second of August until the sixth of September. The plots looked great but set small four inch ears. Wheat yields were about average. Millet yields benefitted the most from the spread out moisture patterns. The plots showed some of the best millet seen in the Akron area. A moderate hail on 12 September reduced yields by approximately 20 percent. This happened immediately after the millet was swathed into windrows. Otherwise, the damage may have been much worse.

Both the minimum and maximum temperatures were above normal for most of the year. Wind runs and average wind speeds for the past year were well above average. Table 2 shows the variability of each growing season since the experiment has been at this location. Table 3 gives the monthly precipitation for the past growing season.

Table 2. Precipitation by growing season segment for Akron 1997-2001.

	Growing Season Segments			
	Wheat		Corn	
	Vegetative Sep - Mar	Reprod. Apr - Jun	Pre-plant Jul - Apr	Growing Season May - Oct
Year	Inches			
1997-98	5.6	2.1	11.1	6.5
1998-99	2.8	7.9	11.4	17.1
1999-2000	5.9	2.7	13.1	9.8
2000-2001	6.3	6.6	12.4	12.3
Long Term Average	5.2	4.1	12.0	11.4

Table 3. Monthly precipitation for the 2000-2001 growing season.

MONTH	AKRON	
2000	**2000**	**Normals[1]**
JULY	2.69	2.69
AUGUST	2.11	2.10
SEPTEMBER	1.58	1.20
OCTOBER	1.91	0.90
NOVEMBER	0.30	0.53
DECEMBER	0.22	0.41
SUBTOTAL	8.81	7.83
2001	**2001**	**Normals**
JANUARY	0.86	0.34
FEBRUARY	0.43	0.37
MARCH	1.02	0.81
APRIL	1.32	1.66
MAY	3.96	2.98
JUNE	1.32	2.45
SUBTOTAL	8.91	8.61
2001	**2001**	**Normals**
JULY	2.66	2.69
AUGUST	2.26	2.10
SEPTEMBER	1.51	1.20
OCTOBER	0.63	0.91
NOVEMBER	0.78	0.53
DECEMBER	0.00	0.41
SUBTOTAL	7.84	7.84
YEAR TOTAL	16.75	16.45
18 MONTH TOTAL	25.56	24.28

[1]Normal = 1961-1990 data base

WHEAT: Wheat yields were about average overall when compared to the area production this year. The highest yielding plot was a wheat-fallow rotation of TAM 107 at 38.4 bushels per acre. While the lowest yield came from a wheat-corn-millet rotation plot of TAM 107 at 23.9 bushels. Overall average of the plots was 30.7 bushels. TAM 107 averaged 30.3 and Prairie Red 31.2 bushels per acre. Table 4 allows comparisons between rotations and varieties with respect to the production of grain and straw. Moisture received during the growing seasons is the reason for differences among 2000 and 2001 yields. There was fifteen percent less precipitation in the 2000 growing season. In most plots, lack of sufficient soil moisture in 2000 reduced both the grain and straw production. Interestingly, Prairie Red has yielded more grain and stover the past two years. All yield data was taken with a Wintersteiger Elite 2000 Series small plot combine.

Table 4. Wheat yield comparisons for year, variety, and rotation.

YEAR	VARIETY	ROTATION	GRAIN YIELD	STOVER
2000	TAM 107	Wheat - Fallow	26.9	3326
2000	Prairie Red	Wheat - Fallow	29.0	3393
2001	TAM 107	Wheat - Fallow	31.2	3353
2001	Prairie Red	Wheat - Fallow	32.3	3936
2000	TAM 107	Wheat - Corn - Fallow	27.6	3583
2000	Prairie Red	Wheat - Corn - Fallow	27.9	3318
2001	TAM 107	Wheat - Corn - Fallow	31.7	3346
2001	Prairie Red	Wheat - Corn - Fallow	29.8	3149
2000	TAM 107	Wheat-Corn-Millet	18.5	1875
2000	Prairie Red	Wheat-Corn-Millet	18.6	2562
2001	TAM 107	Wheat-Corn-Millet	26.2	2577
2001	Prairie Red	Wheat-Corn-Millet	27.0	2572
2000	TAM 107	Wheat-Corn-Sunflower-Fallow	26.5	3818
2000	Prairie Red	Wheat-Corn-Sunflower-Fallow	27.3	3828
2001	TAM 107	Wheat-Corn-Sunflower-Fallow	32.0	3290
2001	Prairie Red	Wheat-Corn-Sunflower-Fallow	35.5	4046

CORN: Corn yields were well below average for the Akron area this year. Soil moisture was good from planting until harvest except for the critical time of seed setting. Although August and September were above average in precipitation, warm weather and almost a month without rainfall hindered ear set and seed development. Many of the ears were three to four inches in length. The plants tried to put on numerous ears which did not help seed quality. Test weights were low with an average of 53.7 pounds per bushel. Many of the plants in 2001 were six to seven feet tall. Area producers had good yields this year. Several claimed over 100 bushel corn. No rain fell at the right time for the plots or yield would have been just as good.

Table 5. Corn yield comparisons by year and rotation for 2000-2001.

YEAR	ROTATION	YIELD	STOVER
2000	Wheat-Corn-Fallow	23.8	1230
2001	Wheat-Corn-Fallow	51.0	2894
2000	Wheat-Corn-Millet	22.2	2635
2001	Wheat-Corn-Millet	58.3	3174
2000	Wheat-Corn-Sunflower-Fallow	12.4	783
2001	Wheat-Corn-Sunflower-Fallow	52.9	3367

MILLET: Millet yields were excellent this past year. Once again, the moisture received during the growing season was more than adequate. If not for the hail mentioned earlier, yields would have approached sixty bushels per acre. Very good for a fairly low input crop. The table shows the relationship of yields and straw production. Keep in mind that the 2000 crop received 8.9 inches of rainfall but the yearly precipitation was over three inches below normal. The 2001 crop received 8.6 inches and was near average at harvest. What a difference three inches of rain can make! Also, the yield for 2000 was changed due to an error in the calculation of acreage taken at harvest.

Table 6. Millet yield comparisons by year for 2000-2001.

YEAR	YIELD	STOVER
2000	14.3	1274
2001	49.1	2200

SUNFLOWERS: This crop is still trying to test my agricultural abilities. With the decrease in rate of Spartan herbicide usage, stands were still decreased. They did not look good but the average yield for the wheat-corn-sunflower-fallow rotation was 1140 pounds. They also generated 2416 pounds of stover per acre. This was far better than anticipated. Yields would have been quite a bit higher if head infesting insects were treated.

RESIDUES: Residue levels have steadily increased in all plots with reduced or no tillage. The plots had no tillage in the past season except for the conventionally tilled wheat-fallow plots. Since 1996, there has only been tillage to incorporate herbicides in the sunflower rotations outside of the conventionally tilled plots. The wheat-corn-millet rotation has showed the most dramatic increase with residues climbing to over 2000 pounds when planting corn. The equipment being used has not had any problems getting through the residue. The table below shows the various levels throughout the plots.

Table 7. Crop residues prior to planting 2001 crops at Akron.

Spring planted crops			Fall planted crops		
2001 Crop	Rotation	Residue (#/A)	2001 Crop	Rotation	Residue (#/A)
Corn	W-C-F	1701	Wheat	W-F	164
Corn	W-C-M	2419	Wheat	W-C-F	1117
Corn	W-C-S-F	860	Wheat	W-C-M	3316
Sunflowers	W-C-S-F	1428	Wheat	W-C-S-F	928
Millet	W-C-M	4612			

WEEDS: Counts are taken each year after harvesting a crop. The measurements are taken to survey the density of weed populations as well as any changes in fauna due to the rotational cropping sequences. This location has not shown any noticeable changes in either. There tends to be more weeds present during the years with greater precipitation. Volunteer wheat, Sandbur, Downy Bromegrass and Foxtail millet are the most prominent from year to year. Other weeds observed in low numbers include the following: Witchgrass, volunteer Proso millet, Pigweed, Kochia, Russian thistle, Puncture vine, Tumblegrass, Japanese Bromegrass and Jointed goatgrass. Table 8 lists the weeds observed this past year.

Table 8. Percent weed cover by crop and rotation at Akron - 2001.

Crop	Rotation	Vol. Wheat	Sandbur	D. Brome	Foxtail	Kochia	Goatgrass	R. Thistle
Wheat	W-F	3.00		0.25	1.00	5.00	0.75	
Wheat	W-C-F	1.25	2.25			0.50		
Wheat	W-C-M	2.00	3.50		1.50			
Wheat	W-C-S-F	0.25	2.00		0.75	0.50		
Corn	W-C-F	0.25	1.50			1.50	0.50	
Corn	W-C-M		2.50		1.50	1.00		0.25
Corn	W-C-S-F	0.25	7.00		1.25	1.50		1.00
Millet	W-C-M		2.00		1.00	0.50		
Sunflowers	W-C-S-F		3.00		1.00	1.00		1.50

*Weeds not listed were less than 0.25% cover.

RESULTS - ENTOMOLOGICAL DATA

WHEAT: Since 1996, no pest populations have reached economic levels. Wheat pests were present in low numbers throughout the growing season. Mites and aphids were the prevalent insect pests. Neither accounted for economic damage. Russian wheat aphids *Diuraphis noxia* Mordvilko per 100 random tillers did not exceed three when put in Berlese funnels for 24 hours. Only six were observed through sampling at spring regrowth, tillering and boot growth stages.

No Bird-cherry oat aphids *Rhopalosiphum padi* Linn or Greenbugs *Schizaphis graminum* Rond were found in the Berlese funnels after sampling. Onion thrips *Thrips tabaci* Linderman were found in low numbers throughout the growing season. They did not become an economic threat. Ladybird beetles were the primary predators in the wheat. A couple of species of spiders were also observed. Pale western cutworms *Agrotis orthogonia* and Army cutworms *Euxoa auxiliaris* Grote were present in the Akron plots at low levels. Total counts for three sampling dates tallied five Pale western and four Army cutworms. Five random sites per wheat variety were dug up to find the larvae. One square foot centered over the rows was used for the samples.

Brown wheat mite *Petrobia latens* (Müller) infestations were very low this year. Sampling was performed with a Vortis insect sampler. Eight mites in a plot of wheat was the most observed throughout the growing season. Interesting results were the total number of mites caught during sampling at regrowth, tillering and boot equaled each other in the susceptible and resistant varieties. Total number of mites per variety were eleven. Rainfall events spread throughout the spring and early summer kept the mite populations in check. There were no predatory mites observed this year. Refer to Table 9 for a list of insects noted in the wheat plots.

Table 9. Wheat insects at Akron for the 2000-2001 crop.

		Total Number By Rotation			
Date	**Insect**	**W-F**	**W-C-F**	**W-C-M**	**W-C-S-F**
22 March	Russian wheat aphid (#/400 tillers)	0	0	1	0
	Brown wheat mite (#/7 ft.^{2})	1	0	0	0
	Army cutworm (#/20 ft.^{2})	0	0	1	0
	Pale western cutworm (#/20 ft.^{2})	0	1	0	0
19 April	Brown wheat mite (#/7 ft.^{2})	0	4	3	0
	Army cutworm (#/20 ft.^{2})	3	0	0	0
	Pale western cutworm (#/20 ft.^{2})	0	3	1	0
15 May	Russian wheat aphid (#/400 tillers)	3	0	0	2
	Brown wheat mite (#/7 ft.^{2})	0	6	8	0

* Insects not listed were not found during sampling.

CORN: Insect pests in the corn were not of economic importance. There were very few cutworms found this year. Aphid species present were Greenbugs *Schizaphis graminum* Rond, Bird-cherry oat aphids *Rhopalosiphum padi* Linn, and Corn leaf aphids *Rhopalosiphum maidis*. None of these were found at threatening levels in any of the crop development stages. Onion thrips *Thrips tabaci* Linderman were also noted but did not pose a threat to plant health. Corn earworm *Heliothis zea,* Corn rootworm *Diabrotica virgifera* LeConte and Sap beetles *Carpophilus lugubris* M. were all present in the plots but did not show up during sampling. Since no insects were detected with greater numbers than five (thrips) per evaluation of a plot, no table of insects has been included. Table 10 is included for this crop to show pheromone trap catches.

Table 10. Pheromone trap catches in corn at Akron - 2001.

Insect	Total Captured	High Catch 24 Hours	Peak Date
Corn Earworm	61	31	06 August
Western Bean Cutworm	19	4	20 July

* Traps put out 02 July 2001.

MILLET: Greenbugs *Schizaphis graminum* Rond and Bird-cherry oat aphids *Rhopalosiphum padi* Linn were the only notable pest insects in the crop this year. The number of aphids was well below economic thresholds. Spiders were the main predators seen in the plots. Also, Ladybird beetles were present to help control the pests. Highest populations of any insect were the spiders at four. Hence, no table for this crop either.

SUNFLOWERS: Pests were abundant this year in the sunflower crop. No cutworms were found while sampling. Aphids did not become a problem as only the non-grain aphids were present. Spotted sunflower stem weevil *Cylindrocopturus adspersus* Leconte did not cause any lodging due to the late planting date. Main pests which were of economic levels follow: Sunflower head moth *Homoeosoma electellum* Hulst, Banded sunflower head moth *Cochylis hospes* Walsingham, and the Red seed weevil *Smicronyx fulvus* Leconte. The seed weevil counts in Table 11 include Grey seed weevil *Smicronyx sordidus* Leconte. There were not economic numbers of this species in the plots. Only one Grey weevil was noticed while sampling.

Table 12 shows the moth flight activity for the head moth species being evaluated. Flight activity at the plots was relatively low. This year seemed to be a good year for the moths in fields throughout northeast Colorado. For reasons unknown, they did not show up in substantial numbers when counting was completed by pheromones. Lures were changed regularly and the jugs were kept full of liquid. Infestation of the heads by the moth larvae would have suggested much higher moth catches.

Predators were scarce in this crop. Of the three dates, the early sampling date yielded the most. That was one Lacewing and two spiders. There were some ladybird beetles in the plots but were not present on the sampled plants.

Other notes on the sunflower crop should be included. Thirteen-striped ground squirrels have been a real concern in the past. This varmint is starting to get tired of being continually harassed with rodenticides and other measures of control. The population has declined to the point where crop damage is slight. Next year may be a different story altogether. Also, the local rabbit family has moved on for the time being. Sunflowers may actually have a chance to show us what they can do for a rotation without these pesky critters.

Table 11. Pest insects in sunflowers 2001.

	DATE		
	28 June	07 Sept	23 Oct
AKRON:			
Cutworms (% cut plants)	-	-	-
Stem weevil (#/stalk)	-	-	4.5
Seed weevil (#/head)	-	4 adults	18.0 larvae
Sunflower moth larvae (#/head)	-	5.0	12.5
Banded sunflower moth larvae	-	2.0	4.5
Aphids (#/plant)	6.0	11.5	-

Table 12. Pheromone trap catches in sunflowers at Akron - 2001.

Insect	Total Captured	High Catch 24 Hours	Peak Date
Head Moth	24	3	02 August
Banded Head Moth	29	7	30 July

* Traps put out 02 July 2001.

Table 13. Weed control methods including herbicide rate or tillage, cost and date applied at Akron in 2001 season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:	Clarity 2,4-D Roundup	3 oz/A 6 oz/A 32 oz./A	0.21 l/ha 0.42l/ha 2.33 l/ha	$1.75/A $0.69/A $9.64/A	01 May 2001 01 May 2001 27 June 2001
Fallow:	tandem disc sweep tillage sweep tillage sweep tillage sweep tillage			$7.00/A $5.50/A $5.50/A $5.50/A $5.50/A	12 Sept 2000 01 May 2001 24 May 2001 14 Aug 2001 24 Sept 2001
Rotation: Wheat-Corn-Fallow					
Wheat:	Clarity 2,4-D	3 oz/A 6 oz/A	0.21 l/ha 0.42l/ha	$1.75/A $0.69/A	01 May 2001 01 May 2001
Corn:	Roundup Glyphomax	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	$9.64/A $5.60/A	18 May 2001 19 July 2001
Fallow:	Roundup Roundup Roundup	32 oz/A 32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha 2.33 l/ha	$9.64/A $9.64/A $9.64/A	17 May 2001 27 June 2001 24 Sept 2001
Rotation:Wheat-Corn-Millet					
Wheat:	Clarity 2,4-D	3 oz/A 6 oz/A	0.21 l/ha 0.42l/ha	$1.75/A $0.69/A	01 May 2001 01 May 2001
Corn:	Roundup Glyphomax	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	$9.64/A $5.60/A	18 May 2001 19 July 2001
Millet:	Roundup Roundup	32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha	$9.64/A $9.64/A	17 May 2001 09 June 2001
Rotation: Wheat-Corn-Sunflower-Fallow:					
Wheat:	Clarity 2,4-D	3 oz/A 6 oz/A	0.21 l/ha 0.42l/ha	$1.75/A $0.69/A	01 May 2001 01 May 2001
Corn:	Roundup Glyphomax	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	$9.64/A $5.60/A	18 May 2001 19 July 2001
Sunflower	Roundup Spartan Prowl	32 oz/A 2 oz/A 38 oz/A	2.33 l/ha 0.14 l/ha 2.77 l/ha	$9.64/A $5.47/A $6.30/A	18 May 2001 09 June 2001 09 June 2001
Fallow:	Roundup Roundup Roundup	32 oz/A 32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha 2.33 l/ha	$9.64/A $9.64/A $9.64/A	17 May 2001 27 June 2001 24 Sept 2001

CHEMICAL CONTROL OF SPOTTED SUNFLOWER STEM WEEVIL WITH PLANTING AND CULTIVATION TREATMENTS, CENTRAL GREAT PLAINS RESEARCH STATION; AKRON, CO

Mike Koch, Assefa Gebre-Amlak

Each plot contained four rows fifty feet long on thirty inch centers. There were six plots per replicate arranged in six replicates of a randomized complete block design.

Planting time treatment of Furadan 4F at 1.0 lb Ai/acre was applied on 19 May 2001. The planter was a John Deere Maxi-Merge equipped with a CO_2 powered micro-tube directed into the seed furrow ½ inch above the seed. Cultivation treatments were applied on 30 June at the V6 to V8 growth stage. A CO_2 powered sprayer with a nozzle (11001 VS-TJ) positioned six inches over the whorl mounted on an Orthman cultivator was used to apply the twelve inch band of insecticide at 17.5 psi of pressure. At the time of cultivation, Spotted sunflower stem weevil densities were four adults per three plants. Beginning 30 October, four plants per plot were dissected. Stalk diameter was noted and sunflower stem weevil larvae in the lower 18 inches of each stalk were counted. Tunnel length of each larvae was measured to the nearest centimeter when possible. Difficulty in following the tunnels made this measurement a time consuming task.

Harvesting was performed by clipping the heads in two rows, 17.5 feet long in the center of the plot. Thrashing was performed by an Almaco stationary small plot thrasher. The seed was cleaned with an aspirator and weighed to the nearest tenth of a gram for yield. A sub-sample of one pound was taken to Hall Grain Company in Akron, Colorado for seed sizing. They used a Ferrell-Ross Clipper separating unit to sort the seeds using a 20 mesh screen to obtain the percent large seeds.

Larvae counts, tunnel length, lodging, stem diameter, yield and seed size over 20 were subjected to analysis of variance and mean separation by the Student-Newman-Keuls method.

When compared to the untreated check no treatment was statistically different in any of the parameters tested (Table 1). This is the first year for trying stem weevil control on confectionary sunflowers. The results may be caused by the sunflower type or by a natural circumstance. Whatever the case, stem weevil densities were high enough to cause economic losses in all plots regardless of treatment. No phytotoxicity was observed throughout the growing season.

FIELD HISTORY :

Pest:	Spotted sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte)
Cultivar:	Triumph 765 Confection seed
Planting Date:	19 May 2001
Plant Population:	16,200
Irrigation:	None
Crop History:	Fallow previous year
Herbicide:	Spartan at 2 oz./acre and Prowl at 38 oz./acre
Insecticide:	None prior to experiment
Fertilization:	No fertilizer applied.
Soil Type:	Weld Silt Loam and Platner Loam, OM 1%, pH 7.0
Location:	USDA Central Great Plains Research Station, Akron, CO.

Table 1. Control of spotted sunflower stem weevil with planting and cultivation timed treatments, Central Great Plains Research Station, Akron, CO, 2001

Treatment	lb AI/acre	Timing	SSW [1] Larvae/Plant	% Lodging	Yield	Seed Size
Warrior T	0.02	Cultivation	34.33 A (21-63)	5.81 A	1425 A	
Baythroid 2E	0.02	Cultivation	30.17 A (7-61)	3.58 A	1361 A	
F0570	0.017	Cultivation	29.50 A (8-61)	6.60 A	1331 A	
Furadan 4F	1.0	At-Planting	29.00 A (14-57)	5.22 A	1442 A	
Untreated		---	28.33 A (12-79)	4.93 A	1351 A	72.5 A
Furadan 4F	0.75	Cultivation	27.17 A (13-57)	3.27 A	1468 A	72.3 A
F value			0.14	0.30	0.13	0.19
Pr > F			0.980	0.910	0.985	0.896

[1] Means in the same column followed by the same letter(s) are not statistically different, SNK (¥=0.05).

FUTURE PLANS: The cropping rotation study will continue to be the main research experiment. The suction trap will be monitored for aphid migration. Observations of Russian wheat aphid populations in northeastern Colorado as well as searching for other economic or threatening pests will carry on. The barley study for resistant varieties to the Russian wheat aphid will continue. Economic injury levels of wheat varieties will keep me busy as well.

SEED YIELD OF SEVERAL SOYBEAN VARIETIES

D.C. Nielsen

PROBLEM: Diversifying dryland production systems in the central Great Plains requires knowledge regarding the productivity of alternative crops. Producers have shown interest in seed production of soybean, yet seed yield for a range of maturity groups grown in this environment is not available.

APPROACH: One Northrup King (NK) and 2 Asgrow (A) seed soybean varieties (maturity groups 2.9 to 3.9) were evaluated for seed yield. Seeding was done directly into wheat stubble with a JD 750 drill with 15 in. row spacing. To evaluate effectiveness of using a stripper header for harvest, hand samples were taken for yield prior to combine harvest in 3, 50 ft^2 areas in each variety, and seeds counted on the ground before and after combine harvest. Combine yield was measured over the entire 1.25 acre area for each variety.

RESULTS: Precipitation during the growing season was 9.4 in. for NK S29-C9 and A3003, and 8.3 in. for A3901. June through September rainfall averages 8.5 in. Hand-harvest yields were similar for all three varieties (20 to 24 bu/a), but much higher than the combine yield over the entire planted area with the stripper header. This is probably the result of many areas in the field having thinner plant stands and lower yields than the hand-sampled areas. We are not able to explain the low final plant stands. In contrast to previous years, there was very little seed loss due to spontaneous pod opening prior to harvest (0.0-0.3 bu/a). Following stripper header combine harvest there was 1.3 to 2.0 bu/a of seed on the ground.

Variety	Maturity Group	Planting Date	Seed Harvest Date	Growing Season Precip	Planting Rate	Final Plant Stand	Hand-harvest Seed Yield	Stripper-header Seed Yield	Yield on ground following Stripper-header
				(in)	(seed/a)	(pl/a)	(bu/a)	(bu/a)	(bu/a)
NK S29-C9	2.9	25 May	20 Sep	9.4	165000	86155	23.8	14.5	1.7
A 3003	3.0	25 May	3 Oct	9.4	165000	88515	19.8	16.6	2.0
A 3901	3.9	1 Jun	11 Oct	8.3	165000	106218	22.9	17.5	1.3

FUTURE PLANS: We will plant these varieties again to gain more experience with soybeans in this environment, and to improve our use of the stripper header with this crop.

FORAGE YIELD OF SEVERAL SOYBEAN VARIETIES

D.C. Nielsen

PROBLEM: Diversifying dryland production systems in the central Great Plains requires knowledge regarding the productivity of alternative crops. Producers have shown interest in forage production of soybean, yet forage yield and quality information are not available.

APPROACH: One commercial (Donegal) and six experimental forage soybean varieties were evaluated for forage yield and quality. Seeding was done on 1 June 2001 with a JD 750 drill with 15 in. row spacing and at a rate of 200,000 seeds/a. Varieties were planted over an irrigation gradient, ranging from no supplemental irrigation (dryland) to 12 inches of supplemental irrigation (wet). Harvest dates are given in the table below.

RESULTS: Precipitation was near the long-term average for June through September (8.5 in.). Forage quality was good for all varieties tested (relative feed value from 129 to 182), with quality decreasing as water availability increased. Dryland forage yields ranged from 3257 (BL38) to 6131 lb/a (97NYCZ-22). The wet irrigation treatment ranged from 9053 (Donegal) to 14359 lb/a (97NYCA-22). Crude protein was not consistently affected by water availability, and no variety was consistently higher or lower in crude protein than any other. Values ranged from 11.0 to 14.9%.Under the dryland conditions, 97NYCZ-22 had the highest yield, crude protein, and relative feed value. OHDP1 and OH49 showed the strongest yield responses to the first 6 inches of irrigation applied.

Variety	Planting Date	Harvest Date			Dry Weight (lb/a)			Crude Protein (%)			Relative Feed Value		
		dry	med	wet	dry	med	wet	dry	med	wet	dry	med	wet
OHDP1	1 Jun	2 Oct	8 Oct	8 Oct	5439	12689	13234	11.7	14.9	11.7	166	155	140
8GH#66	1 Jun	2 Oct	8 Oct	8 Oct	6085	7599	11889	12.9	14.9	13.7	161	129	140
OH49	1 Jun	2 Oct	8 Oct	8 Oct	4832	10543	12552	13.1	13.9	14.6	180	172	150
97VA-18	1 Jun	24 Sep	24 Sep	24 Sep	5547	6638	10625	13.4	13.9	11.0	165	160	142
97NYCZ-22	1 Jun	24 Sep	24 Sep	24 Sep	6131	7114	14359	14.5	14.0	13.4	182	153	140
BL38	1 Jun	24 Sep	24 Sep	24 Sep	3257	5708	9903	14.1	13.9	13.0	163	171	142
Donegal	1 Jun	26 Sep	27 Sep	1 Oct	5602	7209	9053	11.9	11.0	15.3	161	153	149

FUTURE PLANS: Field trials of experimental forage soybean varieties will continue as seed is made available through Dr. Tom Devine, USDA-ARS, Beltsville, MD. We will probably in the future include a commercial seed variety of maturity group 6 or 7 for comparison.

CROP ROTATION AND TILLAGE EFFECTS ON WATER USE AND YIELD OF ALTERNATIVE CROP ROTATIONS FOR THE CENTRAL GREAT PLAINS

D.C. Nielsen, M.F. Vigil, R.A. Bowman, J.G. Benjamin

PROBLEM: Increased use of conservation tillage practices has made more soil moisture available for crop production in the central Great Plains, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Information is needed regarding water use patterns, rooting depth, water use/yield relationships, precipitation storage and use efficiencies, and water stress effects of crops grown in proposed alternative rotations for the central Great Plains.

APPROACH: Nine rotations [W-F(CT), W-F(NT), W-C-F(NT), W-M-F(NT), W-C-M(NT), W-C-PEA(NT), W-SUN-F(NT), W-M-SUN-F(RT), W-SUN-M-PEA(RT)] are used for intensive measurements of water use and water stress effects on yield. (W:winter wheat, C:corn, F:fallow, M:proso millet, SUN:sunflower, PEA:pea CT:conventional till, RT:reduced till). Measurements include soil water content, plant height, leaf area index, grain yield, residue mass and cover, and precipitation.

RESULTS:

Rotation	Crop	ET (in)	Yield (lb/a)
W-F(CT)	wheat	16.2	3120
W-F(NT)	wheat	18.2	3505
W-C-F	wheat	16.6	3269
W-M-F	wheat	16.4	3116
W-SUN-F	wheat	13.2	2391
W-C-M	wheat	11.9	1921
W-C-PEA	wheat	12.6	1961
W-M-SUN-F	wheat	13.9	2477
W-SUN-M-PEA	wheat	12.6	2277
W-SUN-M-PEA	pea	7.3	1189
W-C-PEA	pea	7.0	1074

Rotation	Crop	ET (in)	Yield (lb/a)
W-SUN-F	sunflower	15.1	1156
W-M-SUN-F	sunflower	14.5	1324
W-SUN-M-PEA	sunflower	12.6	920
W-C-PEA	corn	15.5	3600
W-C-M	corn	16.3	3382
W-C-F	corn	16.1	4042
W-M-F	millet	9.5	2367
W-M-SUN-F	millet	10.1	2343
W-C-M	millet	9.4	1927
W-SUN-M-PEA	millet	9.3	1855

INTERPRETATION: Growing season precipitation was near long-term averages for all five crops. resulting in near average yields. Differences in soil water at planting were responsible for differences in water use (ET) and yield for a given crop within various rotations. Response of wheat yield to starting soil water was found to be much higher in normal to wet years vs dry years (5.3 vs 1.5 bu/a per each additional inch of starting soil water). Available soil water at wheat planting was significantly higher in the W-F systems when no-till weed control was employed during the fallow period. Intensifying the W-F no-till system by inserting a crop (C or M) between wheat and the fallow period did not significantly reduce average available soil water at wheat planting nor subsequent wheat yield. Elimination of the fallow period (W-C-M) significantly reduced available soil water at wheat planting and subsequent wheat yield.

FUTURE PLANS: Experiment to continue as in past years. Modeling of yield and water use from this experiment will begin in 2002 with RZWQM and DSSAT-CERES-Wheat.

WATER USE, YIELD AND AGRONOMIC PRODUCTION OF ALTERNATIVE CROPS UNDER AN IRRIGATION GRADIENT

D. C. Nielsen

PROBLEM: Increased use of conservation tillage in the central Great Plains has increased precipitation storage efficiency and made more soil moisture available for crop production, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Future successful and profitable agricultural production will likely be improved with increased diversity of production. Adding new crops to the traditional crops grown in this area will increase diversity. There are many unknowns associated with diversifying agricultural production with alternative crops, such as water requirements, water use-yield functions, rooting patterns, and water stress effects on plant growth, development, and yield.

APPROACH: The plot area was under a solid set, gradient irrigation system. Plots were arranged to provide 4 replications of 4 levels of irrigation, with the highest irrigation level (4) being weekly replacement of water used and the lowest level (1) being rainfed (no supplemental irrigation). Soil water measurements were made with a neutron probe. Water use (ET, evapotranspiration) was computed by the water balance method.

Crop	Variety	Planting Date	Harvest Dates
Forage Pea	Arvika	20 Apr	5, 16, 20, 22 Jul
Chickpea	Myles	20 Apr	13, 27, 30 Aug; 4 Sep
Forage Soybean	Donegal	1 Jun	26, 27 Sep; 1 Oct

RESULTS:

Crop	Gradient Position	Forage ET (in)	Seed ET (in)	Dry Forage Yield (lb/a)	Seed Yield (lb/a)	Forage Crude Protein (%)	NDF (%)	ADF (%)	Relative Feed Value	% Moisture at Forage Harvest
Forage Pea	1	7.4	10.8	4389	N/A	16.0	31.5	28.3	198	73.4
(Arvika)	2	12.1	14.4	7154	1559	13.7	33.2	28.4	189	71.1
	3	13.1	14.8	8843	2679	12.3	40.9	34.8	142	62.7
	4	17.2	18.7	9192	3277	12.5	40.8	35.3	141	63.5
Chickpea	1		13.32		1032					
(Myles)	2		16.92		1417					
	3		19.07		1695					
	4		22.60		2424					
Forage	1	5.61		5602		11.9	38.0	30.1	161	69.4
Soybean	2	7.15		7136		10.7	37.8	31.4	159	69.2
(Donegal)	3	7.96		7282		11.3	39.7	32.9	148	70.5
	4	9.52		9053		15.3	39.9	32.3	149	72.4

INTERPRETATION: All crops showed linear yield increases with increased water use. Both the forage soybean and the forage pea appear to be good quality feeds that would produce 2 to 3 tons per acre of dry matter in average precipitation years.

FUTURE PLANS: Results for chickpea and forage pea will be submitted for publication. Studies will continue with Donegal forage soybean which we will compare with a group 6 or 7 commercial seed variety.

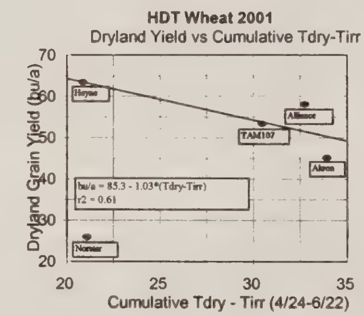
WINTER WHEAT VARIETAL YIELD DIFFERENCES RELATED TO CANOPY TEMPERATURE DIFFERENCES AND SOIL WATER USE

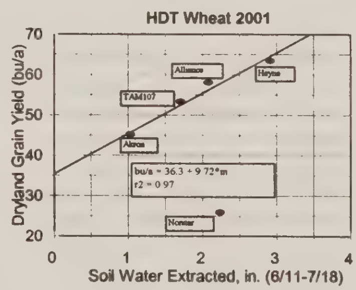
D.C. Nielsen

PROBLEM: Drought stress regularly limits winter wheat yield in the central Great Plains. I hypothesize that varieties that are better able to maintain their non-water-stressed canopy temperatures under water stress will yield higher under water stress than varieties which do not maintain their non-water-stressed canopy temperature under water stress. Monitoring of stressed and non-stressed canopy temperatures will therefore be a quick screening tool to identify varieties adapted to drought stress.

APPROACH: Twelve varieties of winter wheat (TAM107, Jagger, Arlin, Prowers, Siouxland, Akron, Alliance, Norstar, 2137, Heyne, Halt, Yumar) were grown in small plots (15' by 40') under two water treatments (rainfed and full irrigation), replicated three times. Canopy temperatures were monitored daily with an infrared thermometer between 1300 and 1400 MDT. Cumulative difference between canopy temperatures of rainfed and fully irrigated plots was compared to dryland grain yield and biomass for each of the twelve varieties. Soil water was measured in five varieties on 26 Mar, 15 May, 11 Jun, and 18 Jul 2001 to assess differences in soil water extraction.

RESULTS: March through June rainfall (8.56 in.) was 108% of average with May rainfall (5.11 in.) 171% of average. Consequently we did not see severe water stress conditions, and did not see consistent correlations between dryland wheat yield and cumulative dryland-irrigated canopy temperatures as seen in 2000. Dryland wheat yields were correlated with soil water use between 11 Jun and 18 Jul and cumulative dryland-irrigated canopy temperatures for the varieties for which we measured soil water content (except for Norstar which has no adaptation to this environment).





INTERPRETATION: Higher values of Cumulative Tdry-Tirr indicate higher levels of water stress. Grain yield of the dryland treatments increased with decreasing water stress, which was related to increased water extraction between 11 June and 18 July (grainfill to maturity). Of the four adapted varieties shown in the figures, Heyne had the highest yield, lowest water stress, and greatest water extraction. Akron had the lowest yield, highest water stress, and least water extraction.

FUTURE PLANS: The experiment will be repeated next year with no planned changes.

QUANTIFYING LOW WATER AND HIGH TEMPERATURE STRESSES ON WINTER WHEAT YIELD

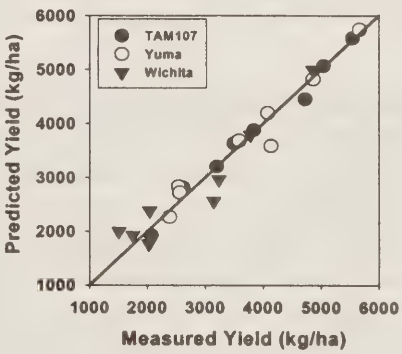
D.C. Nielsen, P.F. Byrne, J.D. Butler

PROBLEM: Drought and heat stress regularly limit winter wheat yield in the central Great Plains. To define areas for optimal wheat production and to determine cultivars that show heat and drought tolerance characteristics, we need to quantify winter wheat responses to these environmental conditions.

APPROACH: Wheat yield data reported by the Colorado Wheat Variety Performance Trials (Colorado State University) for 'TAM 107', 'Yuma', and 'Wichita' (long-term check variety) grown at Akron, CO (1990-2000) were correlated with precipitation and temperature for different time intervals by single-factor regression. After identifying the most sensitive variables individually, we analyzed them jointly via multiple linear regression. Years 1992, 1995, and 1997 were excluded due to frosts at flowering and hail.

RESULTS: Systematic analysis of yield responses to precipitation and temperature identified the most sensitive period as heading through maturity (21 May – 1 July). We identified a 3-parameter multiple regression model that best fit the data: **Yield (kg/ha) = $b_0 + b_1$*Ppt + b_2*N_1 + b_3*N_2** where b_0, b_1, b_2, b_3 = fitted regression coefficients, Ppt = precipitation (cm) from 21 May through 1 July, N_1 = number of days from 21 May through 1 July with maximum temperature between 25 and 35°C, N_2 = number of days from 21 May through 1 July with maximum temperature ≥ 35°C. The model predicts winter wheat yield well for all three cultivars (seeTable and Figure) across a wide range of climate conditions ($1.7 \le$ Ppt ≤ 15.5; $21 \le N_1 \le 31$; $0 \le N_2 \le 8$).

Cultivar	b_0	b_1	b_2	b_3	R^2
TAM107	4773	181.7	-59.0	-181.2	0.99
Yuma	1860	208.1	25.5	-104.5	0.95
Wichita	-1778	229.2	124.2	-98.0	0.90



INTERPRETATION: The identified sensitive period to heat and drought (heading to harvest) is consistent with previous results. Lower relative value of b_1 for TAM107 confirms its drought tolerance characteristic. Less negative and positive values of b_2 and b_3 for Yuma and Wichita may indicate more heat tolerance in these cultivars.

FUTURE PLANS: These results will be combined with the county average yield/climate correlation analysis conducted by Josh Butler and Pat Byrne (CSU) and submitted for publication in 2002.

HEAT AND DROUGHT TOLERANCE IN SPRING WHEAT

D.C. Nielsen

PROBLEM: High temperatures and drought stress regularly limit spring wheat yield in the central Great Plains. Comparing yield and yield components of two varieties of spring wheat, one selected under high temperature conditions, may lead to an understanding of heat and drought tolerance traits that can be incorporated into other varieties through a spring wheat breeding program.

APPROACH: Two varieties of spring wheat (Kauz, MTRWA116) were grown in small plots (approximately 9' by 9') in a rainout shelter under two water treatments (full water replacement and 33% water replacement), replicated three times. Kauz is a hard white wheat from the CIMMYT breeding program (Mexico); MTRWA116 is a hard red wheat from Montana State University. Plots were hand-planted on 29 March 2001 at 80 lb/a with 6 in. row spacing. All plots started with soil water profiles near field capacity. Soil water, plant height, leaf area index, and growth stage were measured weekly. Canopy temperatures were measured daily as conditions allowed.

RESULTS:

Variety	Irrigation	Biomass (lb/a)	Yield (bu/a)	Harvest Index	Water Use (in)	500 Seed Wt. (g)	Seeds per Head
Kauz	Full	8203	54.4	0.39	22.9	13.81	19.81
MTRWA116	Full	8930	42.1	0.27	24.0	10.57	19.77
Kauz	0.33	6884	37.4	0.32	13.7	13.89	13.11
MTRWA116	0.33	7042	36.2	0.30	13.1	12.92	12.39
		------------------------		p	------------------------		
Irrigation		0.016	0.009	0.071	0.000	0.020	0.004
Variety		0.391	0.065	0.001	0.716	0.002	0.819
Irrg X Var		0.575	0.115	0.005	0.210	0.025	0.834

INTERPRETATION: The temperature conditions of 2002 provided an opportunity to determine varietal differences in response to high temperature. Maximum air temperatures in 2002 were warmer than normal, with 17 days between May 1 and July 31 having maximum temperatures greater than 35 C (95 F). Average for the previous 11 years was 9 days. Kauz yielded significantly higher than MTRWA116 under the full irrigation treatment (54.4 vs 42.1 bu/a) but not under the 0.33 irrigation treatment. Visual observations showed problems with tan spot, wheat streak mosaic virus, and stripe rust, which seemed to be more prominent in the MTRWA116 plots than in the Kauz plots, and may have confounded effects of high temperature on yield.

FUTURE PLANS: The experiment will be repeated next year with no planned changes.

SIMULATING CORN AND SOYBEAN YIELD AND DEVELOPMENT UNDER WATER STRESS CONDITIONS WITH RZWQM AND DSSAT MODELS

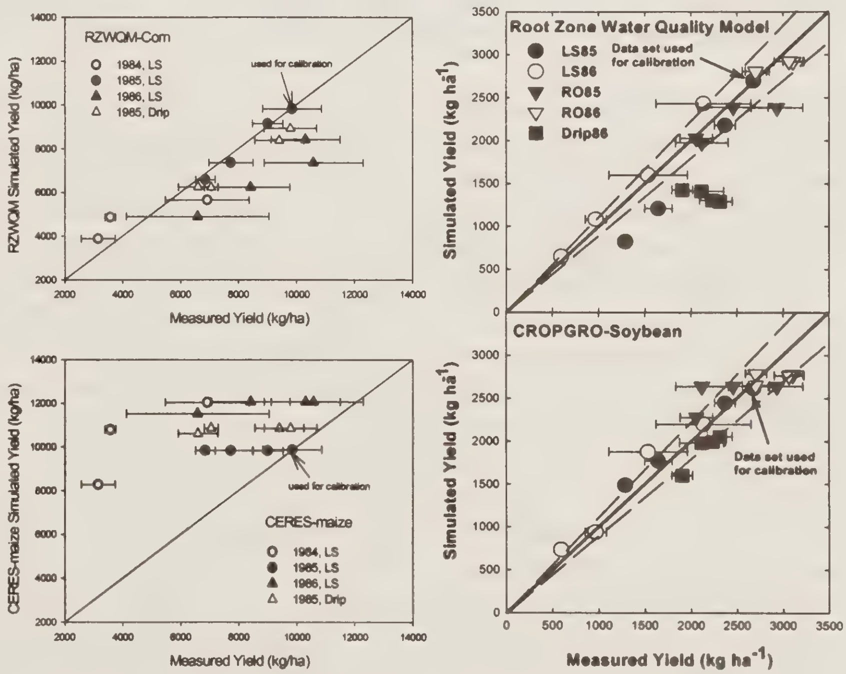
D.C. Nielsen, L. Ma, L.R. Ahuja

PROBLEM: Dryland agricultural production in the central Great Plains is diversifying and intensifying from the traditional wheat-fallow system. Corn has already been added to many rotations, and soybean has been proposed as a possible alternative crop. Computer models exist which could be used to simulate growth, development, and yield of both of these crops and others. But these models have not been adequately calibrated and tested under the limited and variable water conditions of the central Great Plains in which water stress frequently affects plant development and yield.

APPROACH: The Root Zone Water Quality Model (RZWQM), and CERES-Maize and CROPGRO-Soybean as used in the Decisions Support System for Agrotechnology Transfer (DSSAT) were calibrated and evaluated using corn and soybean data collected from line-source, gradient-irrigation experiments conducted at Akron, CO during the 1984, 1985, and 1986 growing seasons. Plant height, leaf area, phenological development, soil water extraction, water use, dry matter development, and grain yield were measured and compared with computer model simulation results.

RESULTS:

RZWQM simulated corn and soybean yield acceptably under all water availability conditions, and provided better simulation of soil water content than CROPGRO-Soybean and CERES-Maize. Predicted corn yields from CERES-Maize did not respond to irrigation. CROPGRO-Soybean predicted soybean yield better than RZWQM.



FUTURE PLANS: The results of these comparisons have been submitted for publication. Future plans call for model evaluations of winter wheat in central Great Plains conditions, followed by simulations of various crop rotations and identification of best adapted crop sequences.

INSECTS IN DRYLAND CROPPING SYSTEMS AT BRIGGSDALE

D.J. Poss

PROBLEM: The Russian wheat aphid (RWA) has become a major pest in small grains in Colorado. Cultural, mechanical, chemical, and biological control methods are all possible. Chemical control has been the most effective however it is costly and is not a long term solution. Combining cultural and biological controls may be the best choice. A diverse cropping system may promote an environment in which the predators can survive.

APPROACH: The plots are 3 miles south of Briggsdale. 1999 was the first season at this site. Prior to 1999, the cropping system was Wheat/Millet/Fallow (WMF). The plots are large compared to most conventional experiments (90 ft X 410 ft) to allow us to study insects. Rotations at this site include two that represent typical rotations for the area (WF and WMF), a longer rotation that allows us to experiment with nontraditional crops (Wheat/Wheat/Corn/Soybean/Sunflower/Forage Soybean) and an opportunity cropping rotation where we crop it as much as possible to maximize biomass production and income. Two wheat varieties are planted in each plot, one is susceptible to the RWA and one is resistant. Insects are counted and collected at the critical growth stages for each crop (three to four stages per crop). To measure the effect rotations have on both pest and beneficial insects. Data collected in 2001 includes yields for all crops, soil N before planting each crop, residues at planting, and pest and beneficial insect populations in all crops.

RESULTS: This is an ongoing experiment where few conclusions will be drawn for several years. The focus of this report is the data collected in 2001. The precipitation received at Briggsdale was below normal in late 2000 and late 2001 and slightly above normal for early 2001. April, May and June 2001 all had above normal precipitation resulting in excellent wheat yields. Precipitation in July, August, and September was well below normal resulting in low yielding summer crops.

Wheat yields averaged 37 bu/ac over all rotations with the wheat in the WF and WMF rotations yielding significantly more than either wheat crop in the continuous WWCSbSfP rotation. The yields between the varieties were not different. The drought had an adverse effect on corn yields averaging 6 bu/ac. The drought played a significant roll in these low yields. Sunflowers averaged 560 lb/ac, also a low yield. Millet yields were excellent, averaging 1.75 T/ac. Its quick growth and its ability to use the June precipitation efficiently help explain these yields. Soybeans were planted, but due to the drought they were not harvested.

Insect populations were very low throughout 2001. No RWA were found and no predator insects were found in the wheat. RWA counts in the suction trap were zero until August. Three RWAs were found in October, a relatively high number for this late in the year. A few army cutworms were found. For the corn, an average of 0.6 Western corn rootworm adults per ear were found, indicating that pressure was low. For the sunflowers there were 4.25 spotted stem weevil larvae per stalk and 2.50 seed weevils per head at maturity. Very few predator insects were found. No insects were found in soybeans due to the dry climate being a poor environment for them. Overall, there were very low numbers of pest and predator insects in all crops.

FUTURE PLANS: Soybeans will be eliminated from the experiment. The six-year rotation will be Wheat/Wheat/Corn/Corn/Sunflower/Fallow beginning in 2002. This is a long term experiment expected to last a minimum of ten years.

For more information email: dposs@lamar.colostate.edu Or call: 970-345-0513

LOW COST SOIL MOISTURE MONITORING EQUIPMENT FOR IRRIGATION SCHEDULING

Joel P. Schneekloth

PROBLEM: Monitoring of stored soil moisture is a key to proper irrigation scheduling. Proper irrigation scheduling can reduce the amount of water applied to crops without reducing grain yields. Environmental benefits include reduced depletion of groundwater and chemical movement below the root zone. However, many of the current tools available for soil moisture monitoring require periodic manual readings. Many producers feel that time constraints do not allow for weekly manual readings of moisture sensors. Current technology has improved to allow for low cost data loggers that read moisture blocks on a time schedule that allows producers less labor requirements to monitor soil moisture for irrigation scheduling.

APPROACH: The demonstration was conducted on an irrigated corn field near Yuma, Colorado with the cooperation of Bryon Weathers. The predominant soil type was sand with a water holding capacity of 1.0 inches per foot. Equipment used in this demonstration included Watermark soil moisture sensors and a AM-400 data logger. Watermark soil moisture sensors are a electrical resistance block with a granular composition similar to the texture of sandy soils. The AM-400 data logger automatically reads the moisture blocks every eight hours. The AM-400 has the capability to store soil moisture readings for up to six blocks during an entire growing season. The data logger has the capability to graphically display soil moisture readings for each block during the last 30 days. Soil moisture readings for the Watermark moisture blocks were compared to weekly measurements using the hand-feel method to determine the moisture status of the soil.

RESULTS: The Watermark blocks readings were comparable to the hand-feel method. Advantages of the blocks with the data logger include multiple readings of soil moisture between manual readings. A season long graph of soil moisture readings is shown in Figure 1. The response of the moisture blocks show wetting and drying cycles of the soil moisture. The response of the blocks when wetting show that within 8 hours, the readings in the 1st foot have increased to field capacity. Changes of soil moisture in the 2nd foot are similar to the 1st foot after wetting. However, the 2nd foot did not generally increase to field capacity after wetting. Figure 2 shows the difference in soil moisture readings between two sets of Watermark blocks. In general, soil moisture readings between blocks were similar for a majority of the season. There were differences in moisture readings in the 1st foot for a 20 day period. Differences in soil moisture were generally less than 0.5 inches. These differences may be due to variability in soil moisture or incorrect installation of that moisture block. The producer did renozzle the center pivot shortly after the time period.

CONCLUSION: The data logger system for reading soil moisture blocks shows promise for irrigation scheduling. Multiple readings per day and graphical display of the soil moisture readings will allow producers to determine if current irrigation scheduling is adequate. Management changes to increase the time interval between irrigations can be made if soil moisture readings are not showing adequate drying cycles and irrigations intervals can be shortened if soil moisture becomes increasingly drier between irrigations.

Figure 1. Soil moisture readings every eight hours for the 1st, 2nd, and 3rd foot using the AM-400 data logger and Watermark soil moisture blocks.

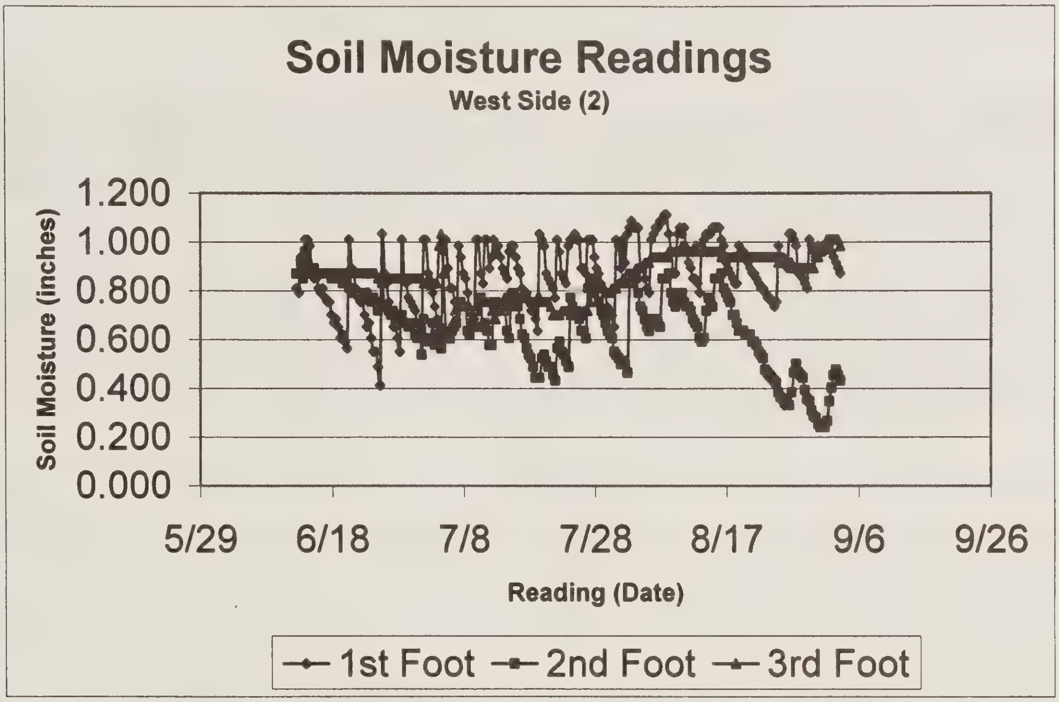
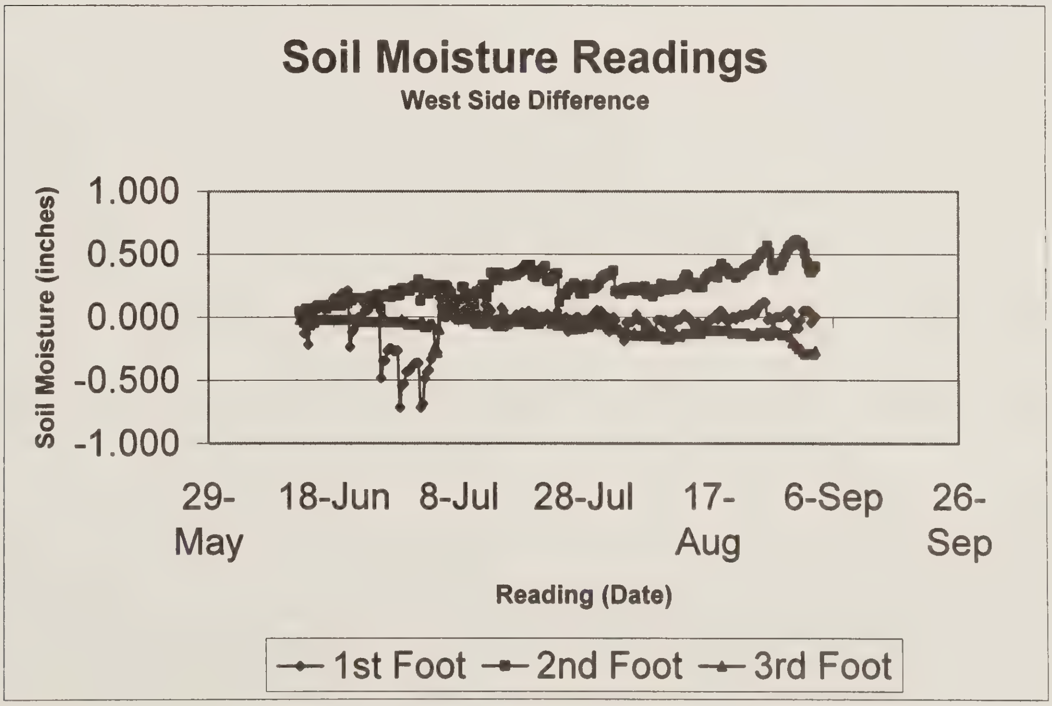


Figure 2. Differences in soil moisture between two sets of moisture blocks at the same depths.



IRRIGATED FORAGE PRODUCTION: AN ALTERNATIVE TO IRRIGATED CROPS

Joel P. Schneekloth and D. Bruce Bosley

PROBLEM: Economics of irrigated crop production are unfavorable with low crop prices. There are few alternatives to traditional crops for producers. However, producers with livestock have the option of irrigated forages. Alfalfa is the predominant forage produced with irrigation. Producers may look at alternatives such as irrigated pastures.

APPROACH: Perennial grass and legume mixtures were seeded in 2001. Grasses include cool and warm season varieties. The grasses will be harvested at optimum stages for maximum nutrient value and production. Forages will be analyzed for crude protein and relative feed value. Plots were irrigated with a hand-move system to meet crop water needs.

RESULTS: Grasses were established during 2001. No harvests were taken during this year.

FUTURE PLANS: The trials will be harvested in 2002 thru 2004 and results will be made then.

LEGUME N CREDITS IN WINTER WHEAT LEGUME ROTATIONS

M.F. Vigil, D.C. Nielsen, R.A. Bowman

PROBLEM: With the exception of water, nitrogen (N) nutrition is the most important limiting input to profitable winter wheat production in the central Great Plains. Increases in N fertilizer costs have caused some farmers to consider alternative systems that include legumes as a source of N. Farmers need to know how these systems impact winter wheat yields, economic returns and N availability. The two sites previously established in which the main plots consist of legume species: Austrian winter peas, spring field pea (cv. Profi), Hairy Vetch and a no-legume-summer-fallow (SF) (plot fertilized at four N rates 0, 30, 60, and 90 lb N/ac are now being used for a two year follow up study. The objectives of the follow up experiment are (1) to determine the fertilizer N response of wheat following the legumes, (2) to determine the N response of the legumes and (3) to determine the difference in N response of the legume wheat rotation as compared to wheat fallow.

APPROACH: Legumes are planted early in April or late March. Weeds growing in the fallow plot are allowed to grow and use water until the legumes are terminated. Legumes and weeds in summer fallow are terminated at the same time, usually the first or 2nd week of June. Before planting wheat in legume stubble each fall, the legume plots are divided into 4 subplots and each subplot is fertilized with either 0, 30, 60, and 90 lb N/ac. Soil inorganic N is measured in each plot, at each termination date, in the top 3 feet of soil, and at wheat planting time to monitor changes in available N. Just after fertilizing legume stubble, wheat is planted. Grain yield is measured using standard BMP's for dryland winter wheat. Equations are fitted to the wheat-grain-yield-response to added N fertilizer for the legume-wheat plots and the wheat-fallow plots. If there is a legume N credit, the N response curve for wheat following the legume plots should be higher on the vertical axis than the fallow N response curve. This is assuming that the weeds use the same amount of water as the legumes.

RESULTS: Nitrogen rates of 30 and 60 lbs/acre increased wheat biomass yields but didn't always show a significant increase in grain yields (table 1). In the wheat plots after fallow, (SF) the highest yields were at the 60 lb N rate (49 bushel/acre). On the other hand, in wheat plots following legumes the highest yields were measured in the check plot with no fertilizer. In general, wheat following the legumes yielded less than wheat following weedy fallow regardless of N rate. The lowest yields were measured in wheat following Profi-pea (table 2).

In the earlier experiment, we measured reductions in wheat grain yields all four years. Eighty-eight % of the variability in wheat yield loss could be described by a equation based on the previous year's legume water use (ET). Generally the highest yield reductions were with the later termination dates. Sometimes the earliest termination dates did not result in a significant reduction in grain yield. Legume green fallow increases wheat-grain-N contents similar to fertilized summer fallow. However, the increase does not increase wheat yield and or cause a large increase in grain-N-uptake when compared to traditional summer fallow. In last year's experiment, we are seeing a similar result. It is interesting that biomass yields tended to increase with added N but didn't always result in increased grain yield. We suspect greater-early-season water use with the 60 and 90 lb N rate plots (bigger plants use more water than smaller ones) than with the 0 and 30 lb N rates. Perhaps less water is available in those plots later in the season during grain filling which depressed yield.

Table 1. Wheat yields as affected by N rate and previous years fallow management.

Treatment	N rate	Wheat grain yield	Wheat biomass yield
Last years fallow management	lbs/acre	bushels/acre	lbs/acre
Fallow	0	41	6500
‘ ’	30	44	7500
‘ ’	60	49	7800
‘ ’	90	44	8400
Austrian winter pea	0	43	7200
‘ ’	30	38	6500
‘ ’	60	39	7600
‘ ’	90	32	7800
Hairy Vetch	0	40	6900
‘ ’	30	35	6500
‘ ’	60	36	7100
‘ ’	90	36	7000
Profi pea	0	35	6300
‘ ’	30	29	6800
‘ ’	60	30	7400
‘ ’	90	29	8200
LSD (0.05)		**9**	**1400**

Table 2. Wheat yields as affected by fallow treatment.

Treatment	Wheat Grain yield	Wheat Biomass
Last years fallow management	bushels/acre	lbs/acre
Fallow	44.3	7600
Austrian winter pea	38.1	7300
Hairy Vetch	36.7	6900
Profi pea	30.1	7200
LSD (0.05)	**4.4**	**698**

FUTURE PLANS: We will conduct the follow up experiment for another year. Four publications have resulted from the study.

ROUNDUP-READY CORN THE EIGHTEENTH CROP OF A DRYLAND ROTATION WITHOUT SUMMER FALLOW

M.F. Vigil, R.A. Bowman. A.D. Halvorson

PROBLEM: Conservation tillage has increased annual soil water storage. This enables the use of annual cropping for some soils of the central Great Plains. Annual cropping entails greater biomass production which increases surface crop residues impacting soil quality and soil water storage. This study was designed to evaluate long term changes in soil C and N under annually cropped dryland conditions under different N fertility. Short term, the study allows for the estimation of N use efficiency and fertilizer N requirements of various dryland crops.

APPROACH: This is the 18th year of the experiment (started by Ardel Halvorson in 1983), where under dryland conditions, the site is cropped continuously with no summer-fallow on a Weld silt loam. The site was a barley-corn rotation until 1992 when oats for hay replaced barley. We have had 15 successful years and three failures in the 17 years of cropping: winter wheat was grown in 1988 to replace a hailed out corn crop in 1987, in 1990, poor stand and aphids limited barley yields to 21 bu/acre, and in 2000, Round-up-ready-soybeans (category 3) made between 8 and 13 bushel. The experiment is a 4-rep RCB where the only treatment is N fertilizer rates of 0, 20, 40, 60, 80 or 120 lbN/acre. The study is managed with no-till to conserve water and weed control has been through the use of contact and residual herbicides. Phosphorous (P) nutrition has not been limiting, but low rates of P have been applied with the seed at planting or as broadcast treatments. Soil profile water and nitrates are monitored annually to determine N balance and water use efficiency.

RESULTS: In 2001 roundup ready (DK493) Corn made 87 bushel with 80 lbs of N (table 1). Yields tended to increase with increasing N rate. Through the years, the optimum N rate for the grain crops has been between 40 and 60 lbs N/acre for wheat and between 60 and 80 lbs for corn.

Table 1. Yields of dryland corn as affected by N rate in 2001 under no-till annual cropping.

N rate	Grain Yield	Test wt
lbs /acre	bushels/acre	lbs/bushel
0	68	55
20	77	55
40	81	55
60	85	55
80	86	54
120	88	54

A buildup of excess nitrate-N can be found in the soil of plots fertilized at 80 lbs or more. These results suggest that with this soil (under dryland conditions) annual fertilizer N rates greater than

80lb/acre are excessive for the crops and management currently available. Triticale yields in 1995 were 5.5 ton/acre at an optimal N rate of 80 lb/acre. In 1996, maximum corn grain yields of 90 bu/acre were measured at the 120 lb N rate. At the 80 lb N rate 75 bu/acre of grain was harvested. In 1997, on 11, July we harvested 900 to 1100 lbs of profi peas with a whole plot average of 1011 lbs/acre. The 1998 crop of winter wheat averaged 26 bushels in the fertilized plots and 22 bushels in unfertilized plots. Corn yields in 1999 were as high as 140 bushels per acre at the 80 and 100 lb N rates. Warm season grasses (sandbur) are becoming a nuisance. In 2000, roundup ready soybean (maturity group 3) was used to help eliminate the sandbur problem. The soybeans were not fertilized with N because residual N levels were large from fertilization in prior years. A visual response of the soybean was observed. The lowest yields were measured in the 80 and 120 lb N/acre plots (8 bushel/acre). The largest yields were measured in the 0 N-rate plot (13 bushel/acre).

FUTURE PLANS: The crops for the next few years will be dormant seeded winter wheat or spring triticale, Round-up ready corn and dry edible beans or millet. The experiment will continue for another 4 years to evaluate long-term soil C and N changes under high N management and high productivity.

NITROGEN RESPONSE OF WHEAT CORN AND SUNFLOWERS IN A DRYLAND ROTATION ROW SPACING EFECTS

M.F. Vigil, J.G. Benjamin, J. Schepers,

PROBLEM: The current demand for edible oils has improved the profitability of sunflowers in the Central Great Plains. However, knowledge of sunflower response to fertilizer N in the region is limited. The objectives here are: (i) to measure sunflower N response in a no-till wheat-corn-sunflower-fallow rotation, (ii) to determine N fertilizer recovery of this crop as affected by fertilizer placement method, and (iii) to compare narrow row (20") production with conventional spacing.

APPROACH: Sunflower is planted and fertilized in a split-plot 4-rep experiment. Main plots consist of rotation crop/phase (sunflowers, corn, wheat or fallow). Sub-plots are fertilizer N rates of 0, 30, 60, or 90 lb N/acre. Sunflowers are planted in either **20 or 30 inch rows**. A seeding rate of 16,600 seeds per acre is used for both row spacings. In the 20 inch row plots, 2 rows are sprayed at the 5th leaf stage and at the early-bud stage with zinc, copper, manganese and boron. Individual plots are 60 ft by 240 ft in size. Surface and deep placed ^{15}N labeled fertilizer is used to evaluate fertilizer N recovery with soil depth and N placement method.

RESULTS: In 2001, a small increase in grain yield to added N was measured in corn. No significant yield response to N was found in the sunflowers. Wheat, as always, responded well to added N. We measured 60 bushel wheat at the 60 and 90 lb N rates with Trego white wheat. No significant yield response due to row spacing was measured. In this study we have had 2 years in which row spacing has not had an effect on yield and one year that it has. In all years, there is a suppression of weed growth that is visually noticeable in the narrower rows. In 2000, a dryer than normal summer with low preplant soil water contents, we measured less than 300 lbs of grain in our best sunflower plots. No row spacing, N rate, or micronutrient responses were detected in 2000 with either sunflowers or corn. Water was more limiting than these other management factors.

FUTURE PLANS: The experiment will be continued for another 4 years to evaluate long term effects of intensive wheat-corn-sunflower fallow rotations and to continue to evaluate N and row spacing effects on yield. We are considering splitting the plots between soybeans and sunflowers, but can't do that until we have finished evaluating the row spacing effect for at least 2 more years.

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